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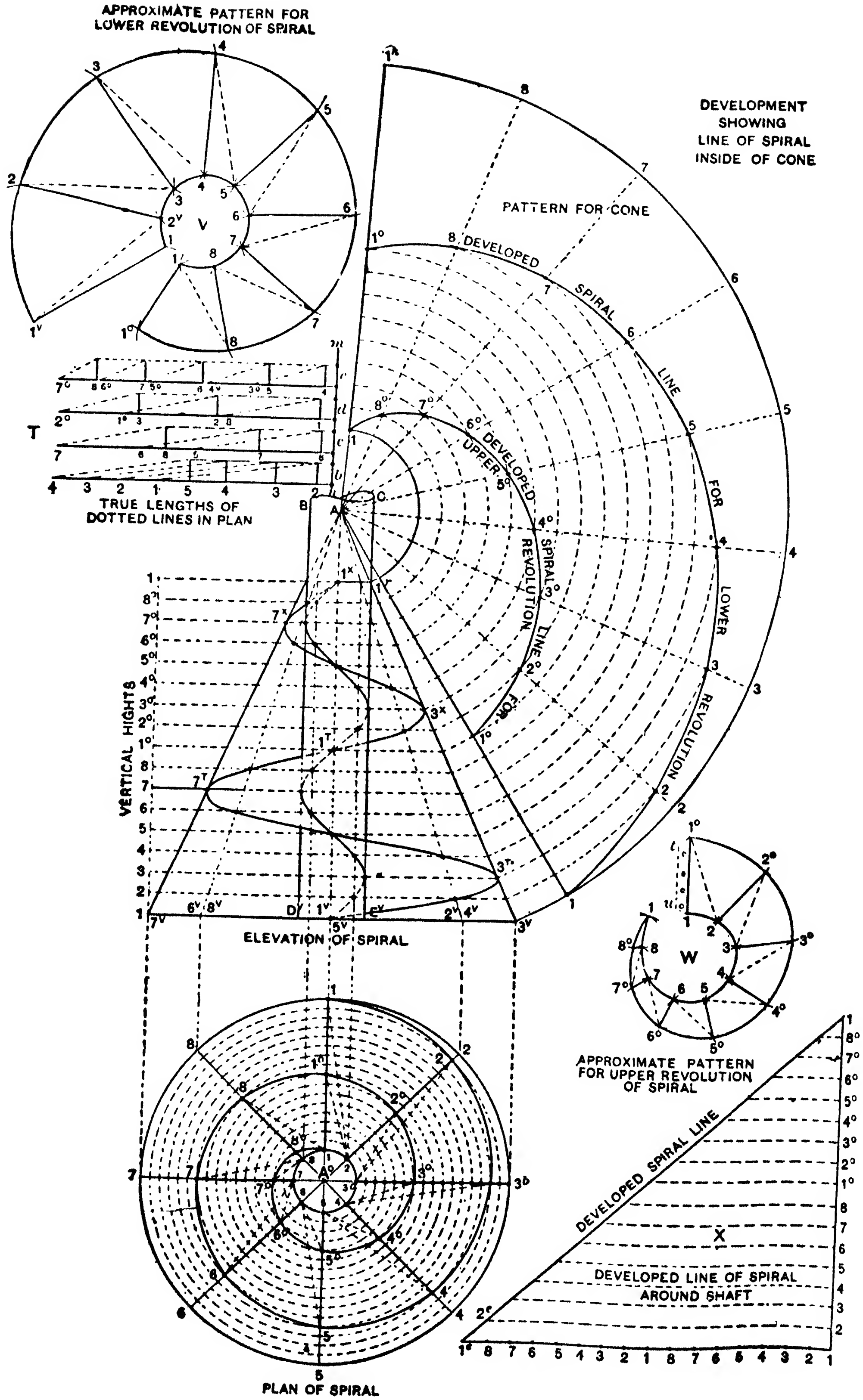

FRONTISPIECE — Patterns for spiral inside a cone. For details see page 289

SHEET METAL PATTERN LAYOUTS

A PRACTICAL, ILLUSTRATED TREATISE COVERING ALL PHASES OF SHEET METAL WORK INCLUDING PATTERN CUTTING

and

PATTERN DEVELOPMENT

for all

SHEET METAL WORKERS, LAYOUT MEN MECHANICS AND ARTISANS

Compiled by EDWIN P. ANDERSON

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Foreword

This work represents a large and valuable group of practical *Sheet Metal Pattern Layout Problems,* presented in a clear and simple language.

It is intended as a *Complete Shop Guide* showing a step by step solution of several hundred sheet metal problems met with in day to day practice by the average sheet metal worker and layout man.

Each problem has been worked out by experts in the numerous fields represented, thus making it virtually *An Encyclopedia of Practical Sheet Metal Work. Special credit is given to William Neubecker for his assistance in the preparation of many of the problems presented.*

> *It cannot be too strongly emphasized however, that TRUE SKILL is reached only by the man who understands that no book, no matter how complete, will give a solution to all problems encountered--but will merely point out the "ROAD TO FOLLOW".*

In reality this is true, for though the exact problem may not appear, there surely is one, the principles of which could be adapted to the problem at hand, with a little adjusting.

Due to the fact that a certain amount of geometrical knowledge is always required, especially in sheet metal patterns of a more intricate nature, the reader is advised to study Section X, which gives a step by step instruction in 50 problems, many of which are actually encountered in laying out of patterns of sheet metal work. Proficiency in the solution of these problems will prove to be of inestimable value wherever expert workmanship is to be attained.

The Publishers.

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SECTION I

(Pages 1-200)

HEATING AND AIR CONDITIONING DUCT PATTERNS

PATTERNS OF INTERSECTION BETWEEN ELBOW AND SCALENE CONE

In Fig. 1 is shown a piece of pipe work, the patterns for which are here developed. This illustration shows two 20-inch elbows connected to two boilers. The elbow A connects to a 20-inch smoke pipe. By means of a transition or scalene cone B the smoke pipe is enlarged to 28 inches in diameter. Into this scalene cone B elbow C connects. For the pattern for the intersection between the elbow and the pipe A, see "Pattern for Elbow Mitering with Round Pipe" on page 41 of this book.

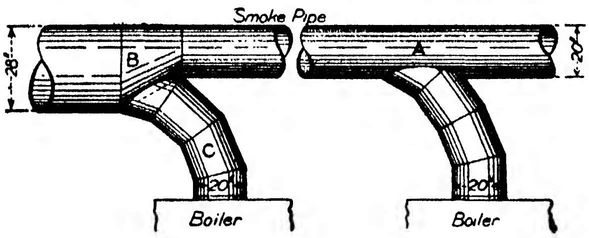


Fig. 1. Sketch of the Problem

For the pattern for the elbow joining the scalene cone B, proceed as is shown in Fig. 2, in which first draw the elevation of the pieced elbow, as is shown by A B C D, and the profile M. Draw the scalene cone W V J S and the cylinder T W V U as shown. As only one section of the elbow H I J K miters with the cone, the problem merely consists of the intersection of a cylinder with a scalene cone. Should, however, two sections of the elbow miter with the cone, which would occur if the elbow had more pieces, the same principles as those which would follow would be employed.

Directly below the side elevation draw the plan. Extend J V in elevation until it intersects S T to T. Then will T be the apex of the scalene cone shown in plan by X. Divide the half plan A^1 C^1 X into an equal number of spaces, as shown by the small figures 6 to 12. From these draw lines to the apex X. The elbow will not cut any deeper into the cone than between 7 and 8 in plan, therefore at right angles to X A^1, and from points 7 and 8, erect lines intersecting S J in elevation at 7 and 8. From these draw lines to T.

Now divide the profile M into an equal number of parts by the small figures, from which at right angles to A B draw lines intersecting the miter line G F at

2, 3 and 4. Parallel to G H and from these points draw lines intersecting the miter line H I. Then again parallel to H K draw lines crossing the miter line K J and the radial lines T 6, T 7 and T 8 of the cone, as shown.

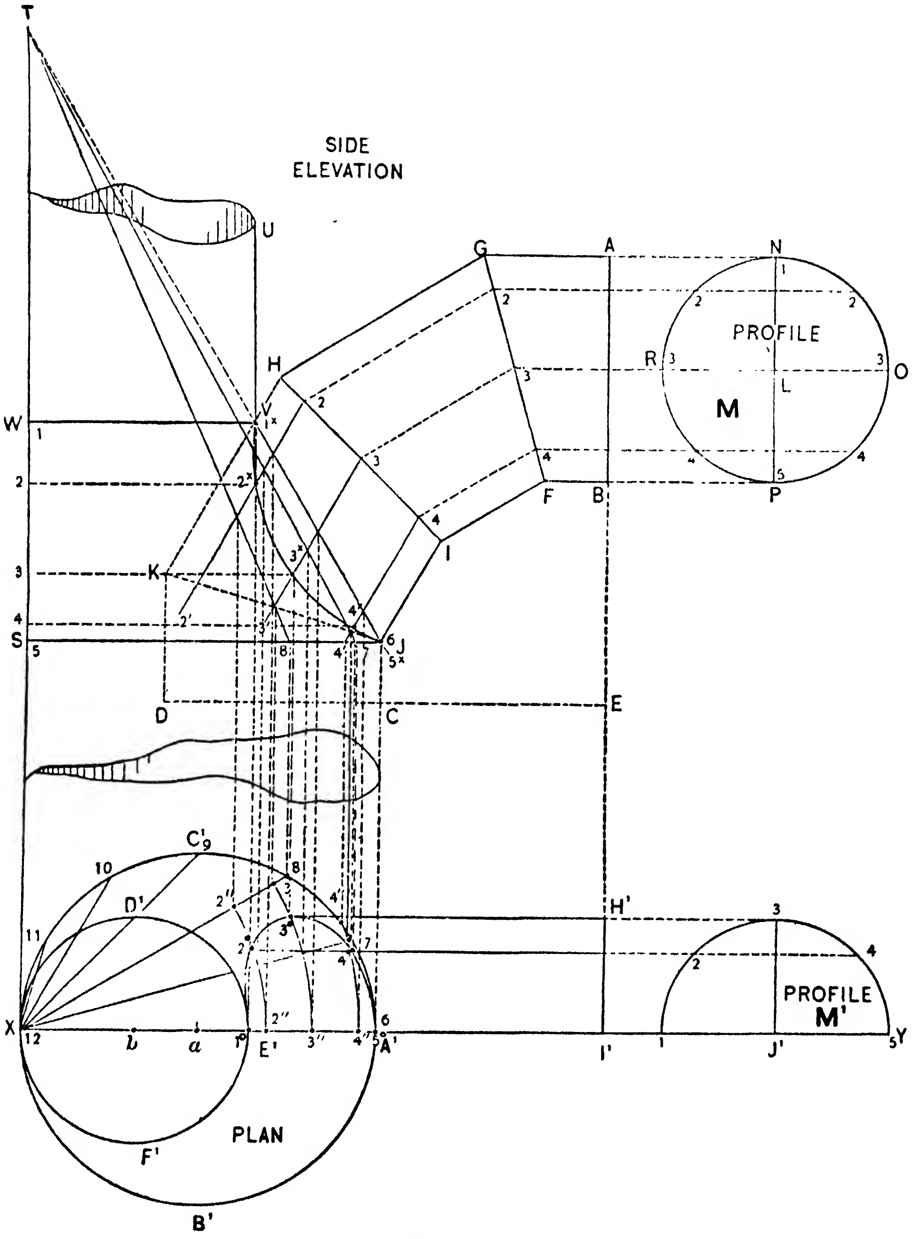


Fig. 2.
Determining the Intersection Lines

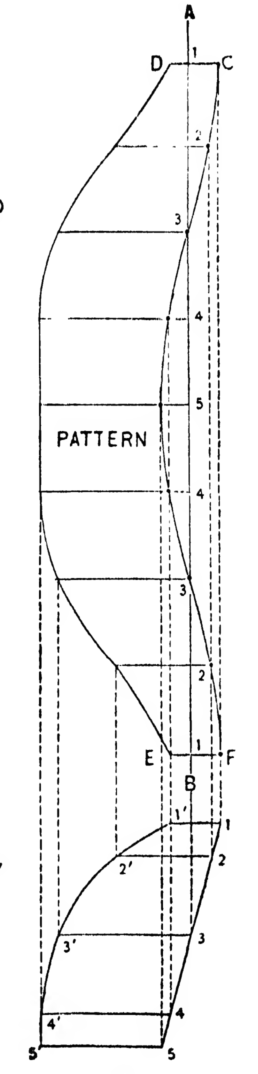


Fig. 3.
Developing the Pattern

The next step is to obtain horizontal sections through the scalene cone on the lines 2 2′, 3 3′ and 4 4′, for which proceed as follows: From the intersections, where the line 2 2′ of the elbow crosses the radial lines T 6, T 7 and T 8 of the

cone, drop lines parallel to W S, intersecting X 6, X 7, X 8, which are similar radial lines in plan. Trace a line through the points thus obtained shown by 2″ 2″, which will represent the half horizontal section on 2 2′ in elevation. In similar manner obtain the section line 3″ 3″ in plan, representing the horizontal section on 3 3′ in elevation: 4″ 4″ represents the horizontal section on 4 4′.

As the center line of the elbow comes directly in the center of the cone, as shown in plan, one half plan is all that is necessary in practice. Extend the center line of the cone X A^1 as shown by X Y upon which place the half profile of M shown by M^1. Divide M^1 into the same number of spaces as contained in one half of M. As 1 and 5 in elevation represent the top and bottom of the elbow respectively, the figures 1 and 5 are placed in the position shown in plan in M^1 and still represent the top and bottom. As the 1 and 5 in M intersect the cone at top and bottom respectively, then must the points 1 and 5 in plan intersect the top and bottom respectively of the cone in plan, as shown by 1° and 5°.

As the points 2, 3 and 4 of the profile M intersect the section lines in elevation 2 2′, 3 3′ and 4 4′ respectively, then must the lines drawn from the points 2, 3 and 4 in the profile M^1 in plan parallel to X Y, intersect the section lines 2″ 2″, 3″ 3″ and 4″ 4″, respectively at points 2°, 3° and 4°. Trace a line through intersections thus obtained, as shown by 1° 2° 3° 4° and 5°, which will represent the line of joint in plan between the elbow and the cone. For the miter line, or line of joint in elevation, draw lines at right angles to X Y in plan, from the intersections 1° to 5° intersecting similar numbered lines in the elbow in elevation as shown by points of intersections, 1^x, 2^x, 3^x, 4^x and 5^x. Through these points draw the miter line V J.

The patterns for the two upper sections of the elbow are drawn in the usual manner. For that of the lower section take a tracing of H I J V and place it in Fig. 3 as shown by 1 1^1 5^1 5. Draw the stretchout line A B and obtain the pattern C D E F in the usual manner. For the pattern for the scalene cone proceed as follows: Take a tracing of J S W V and place it as shown by J S W V in Fig. 4. Also take a tracing of the half plan in Fig. 2 and place it as shown by similar figures in Fig. 4, reversing it, as shown. Parallel to J S in Fig. 2 and from the intersections 1^x to 5^x draw lines intersecting the vertical line W S at 1, 2, 3, 4 and 5. Take these various hights on W S and place them on W S in Fig. 4, as shown. Extend S W and J V until they intersect at T, which is the apex in elevation; 12 represents the apex in plan. Then using 12 as center draw arcs intersecting 12 6 in plan, as shown. From these points at right angles to 12 6 draw lines intersecting S J at 6′, 7′, 8′, 9′, 10′, 11′ and 12′. Draw lines to the apex T.

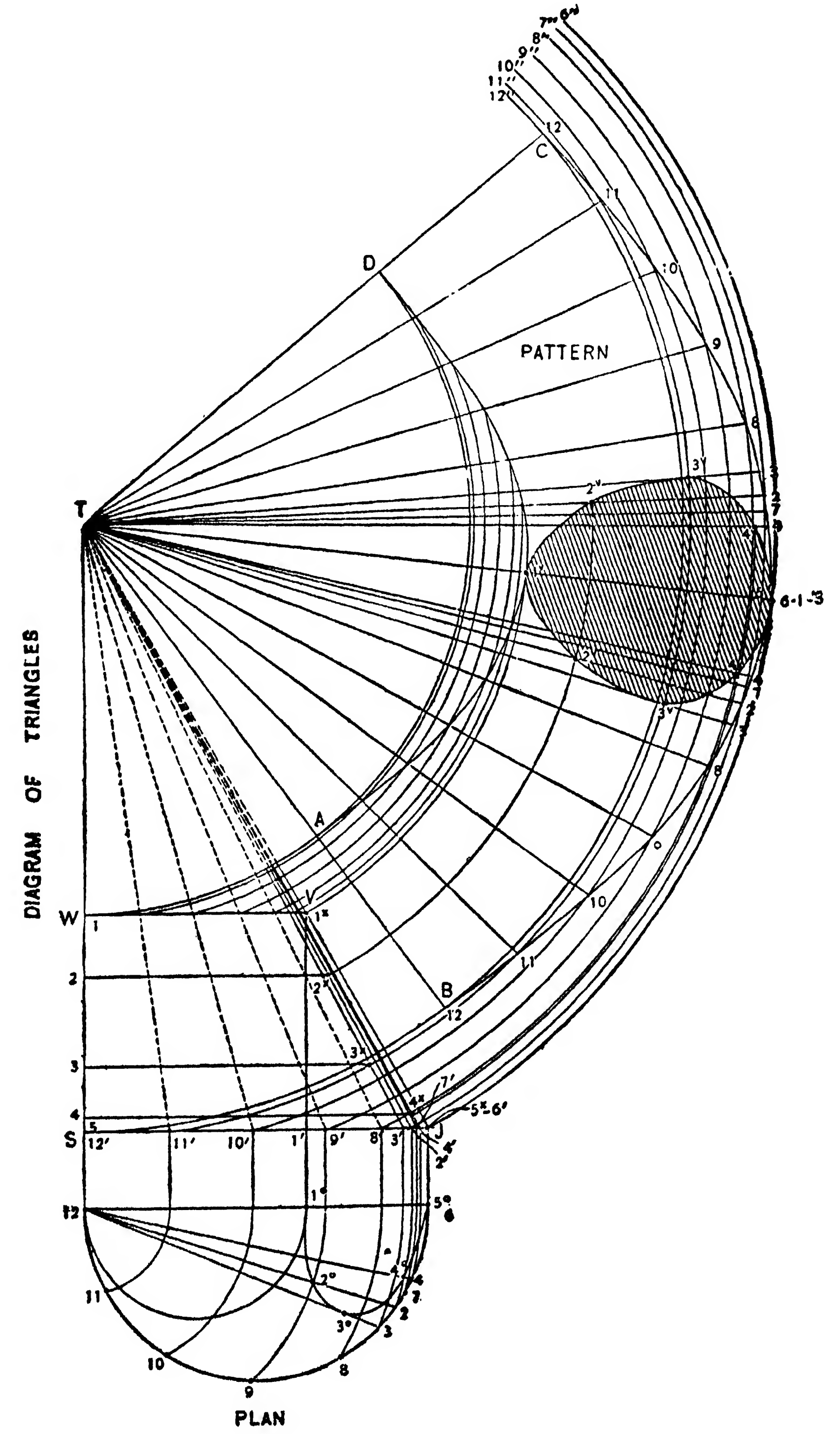


Fig. 4. Developing Pattern and Opening of Scalene Part

Next using the apex T as a center draw the arcs 6′ 6″, 7′ 7″, 8′ 8″, 9′ 9″, 10′ 10″, 11′ 11″ and 12′ 12″, as shown. Set the dividers equal to one of the spaces into which the half plan is divided, and starting from 12 on the arc 12′ 12″, step from one arc to another, having similar numbers, thus obtaining the points 12 to 6 to 12, through which draw the curve shown. From 12, 11, 10, 9, 8, 7, 6, 7, 8, 9, 10, 11 and 12, draw lines to the center T. Using T as a center, and radii equal to the various intersections on W V draw arcs, intersecting similarly numbered radial lines in the pattern, as shown, through which draw the curved line A D. Then will A B C D be the pattern for the scalene cone.

For the opening to be cut in the cone proceed as follows: Through the intersections 2°, 3° and 4° in the plan in the miter line, draw lines to the apex 12, extending them until they intersect the semicircle at 2, 3 and 4 respectively. Then using 12 as a center, describe arcs intersecting the center line 12 6 as shown. At right angles to 12 6, and from these intersections draw lines intersecting S J at 2′, 3′ and 4′. From these points draw lines to T. It will be noticed that the points 1° and 5° in plan intersect the line W V at 1^x, and the line S J at 5^x, respectively.

At right angles to S T and from the intersections 2, 3 and 4 on W S, draw lines intersecting the radial lines T 2′, T 3′ and T 4′, as shown at 2^x, 3^x and 4^x. Take the distance from 7 to 4 in plan and place it on the curved line B C in pattern, as shown from 7 to 4 on both sides. In similar manner take the distances from 7 to 2 and 8 to 3 in plan, and place them on the curved line B C of the pattern, as shown from 7 to 2 and 8 to 3 respectively on both sides. From the points 3, 2, 4 and 4, 2, 3 on the curved line B C, draw lines to the apex T, which intersect with arcs drawn from 2^x, 3^x and 4^x, using T as center, thus obtaining the intersections in the pattern 2^v, 3^v, 4^v, on either side. Trace a line through points thus obtained as shown by the shaded portion, which will be the required opening.

PATTERNS FOR ELBOW WITH DOUBLE OFFSET

To obtain patterns for a double elbow, as shown in elevation in Fig. 5, the vertical hight of which is equal to *a b* and the offset equal to *c d*, the profiles of the pipes being oblong with semicircular ends, proceed as follows:

In work of this kind it is not necessary to draw the foreshortened elevation shown by *e a*. All that is required is the plan view, from which an oblique

elevation is drawn, as shown in Fig. 6, in which C represents the profile of the upper elbow and D a similar profile for the lower elbow, the offset between the two being equal to the distance B. Connect the two profiles by the lines E and F, which completes the plan view, from which the oblique elevation of the elbow is drawn at right angles to the plan line E as shown by the pieces I to V, the vertical hight of the elbow being equal to the distance A. Care should be taken in drawing the oblique elevation of the elbow to have all angles and miter lines alike, so that the pattern cut for one piece will answer for all five. Now through the centers *a* and *b* of the semicircular ends in the profile D draw lines at right angles to the flat sides of the profile D, as shown by 6, 10 and 1, 5. Then divide the semicircular ends into equal parts as shown by the small figures 1 to 10. At right angles to the plan lines E or F, from the small figures 1 to 10 in D erect lines until they intersect the first miter line as shown by similar numbers. Extend the line X H in elevation as shown by J K, upon which place the stretchout of the profile D as shown by similar numbers 1 to 10 to 1. Through these small figures at right angles to J K draw lines indefinitely as shown, which intersect by lines drawn parallel to J K from similar numbered intersections on the miter line in elevation. Trace a line through points thus obtained, then will 1 L M 1 be the pattern for piece I, also the miter cut for all the other pieces.

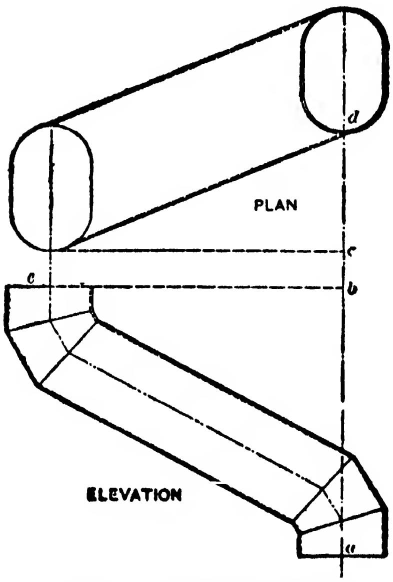


Fig. 5. Sketch Submitted

To obtain the balance of the patterns from one piece of metal without waste, proceed as follows: As the outline of the elbow in elevation is in line with points 2 and 7 in the profile D, then upon lines drawn from 2 and 7 in the pattern must the measurements be placed. Therefore at right angles to J K from points 2 and 7 draw lines indefinitely as shown. Now take the distance from 7 to 7′ in elevation and place it on line 2 in the pattern as shown by *i j*. In a similar manner take the distance from 2 to 2′ in elevation and place it on line 7 from *c* to *d*. Next take a tracing of the miter cut L *i c* M, reverse it so that the points *i* and *c* will come upon *j* and *d*, and obtain the miter cut O *j d* N. Then will L M N O be the pattern for piece II.

Take the distance in elevation of either 7′ 7″ or 2′ 2″, as they are both alike, because the miter lines run parallel to each other, and place it as shown from

j to *k* and *d* to *e* in the pattern, and trace the miter cut O *j* *d* N, having *j* *d* come on *k* *e* without reversing the cut, and obtain the miter cut P R. Then will N O P R be the pattern for piece III.

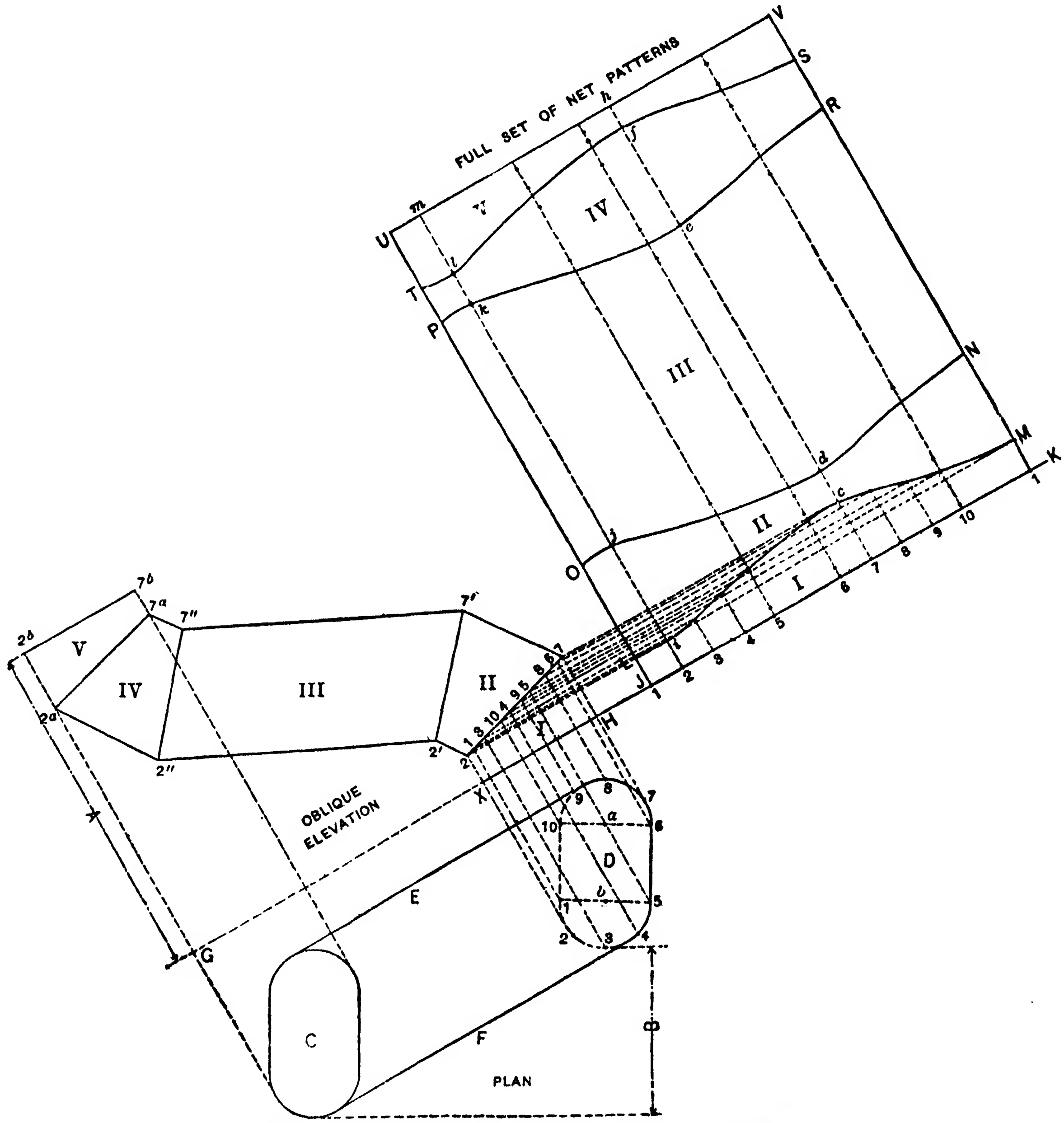


Fig. 6. Details of Pattern for Double Elbow With Offset

Next take the distances from 2″ to 2^a and from 7″ to 7^a in elevation and place them as shown in the pattern, from *e* to *f* and *k* to *l* respectively, and trace the miter cut P *k* *e* R, reversing it so that *k* and *e* will come over *l* and *f* and obtain the cut T S. Then will P R S T be the pattern for piece IV.

Finally take the distances from 2^a to 2^b and 7^a to 7^b in elevation and place them in the pattern as shown respectively from *l* to *m* and *f* to *h* and draw a line through these two points *m* and *h* until it is intersected by lines erected from points 1 and 1 in the pattern. Then S T U V is the pattern for piece V.

It should be noted that these patterns are net—that is no allowance has been made along the miter cuts for seaming or riveting. In practice the amount of this edge must be added to the various pieces parallel to the miter cut.

PATTERNS FOR THREE-PIECED TRANSITION ELBOW HAVING AN OFFSET

For the pattern of a round to an oval three-pieced elbow with regular 45 degree backset, the transition to be in the middle section and oval section to be offset, proceed as follows:

In Fig. 7 are shown several of the conditions laid down. The length of the oval profile X is equal to the diameter of the round profile Y. The first step is to draw a proper side elevation of the elbow as follows: On a horizontal line, A C, set off the distance of the throat A B and the diameter of the round pipe B C. From A erect the perpendicular line A E equal to A C, and using A as a center draw the quadrants B D and C E. From B and C erect perpendicular lines and from D and E draw horizontal lines. Intersect these by the two lines drawn tangent to the quarter circles at *a* and *b* at angles of 45 degrees. Draw the miter lines 6 1 and 5′ 1′ and this completes the side elevation of the elbow.

In line with E D draw the profile X of the oval pipe, and in line with B C the profile of the round pipe Y. Divide both semicircles in both the oval profile X and round profile Y into similar number of parts as shown. From the various divisions 1 to 10 in the profile X draw lines at right angles to E D, or parallel to E 6, until they cut the miter line 6 1 from 1 to 10. Extend the line D E as H J, upon which place the girth of one half the profile X as shown by the small figures 1 to 6 on H J. From these small figures at right angles to J H draw lines which intersect by lines drawn parallel to H J from similar numbered intersections on the miter line 1 6. Trace a line through intersections thus obtained; then will 6 6″ 1″ 1 be the half pattern for the oval pipe, with seams at 1 and 6 in profile X. If the full pattern is desired with seam at 1, then reverse K on the line 6 6.″

From the various intersections in Y erect vertical lines at right angles to B C until they cut the miter line 1′ 5′ as shown. To obtain the pattern for the round pipe erect any vertical line, as B^1 C^1, and place the girth of one half the profile Y as shown by the small figures on B^1 C^1. Through these small figures at right

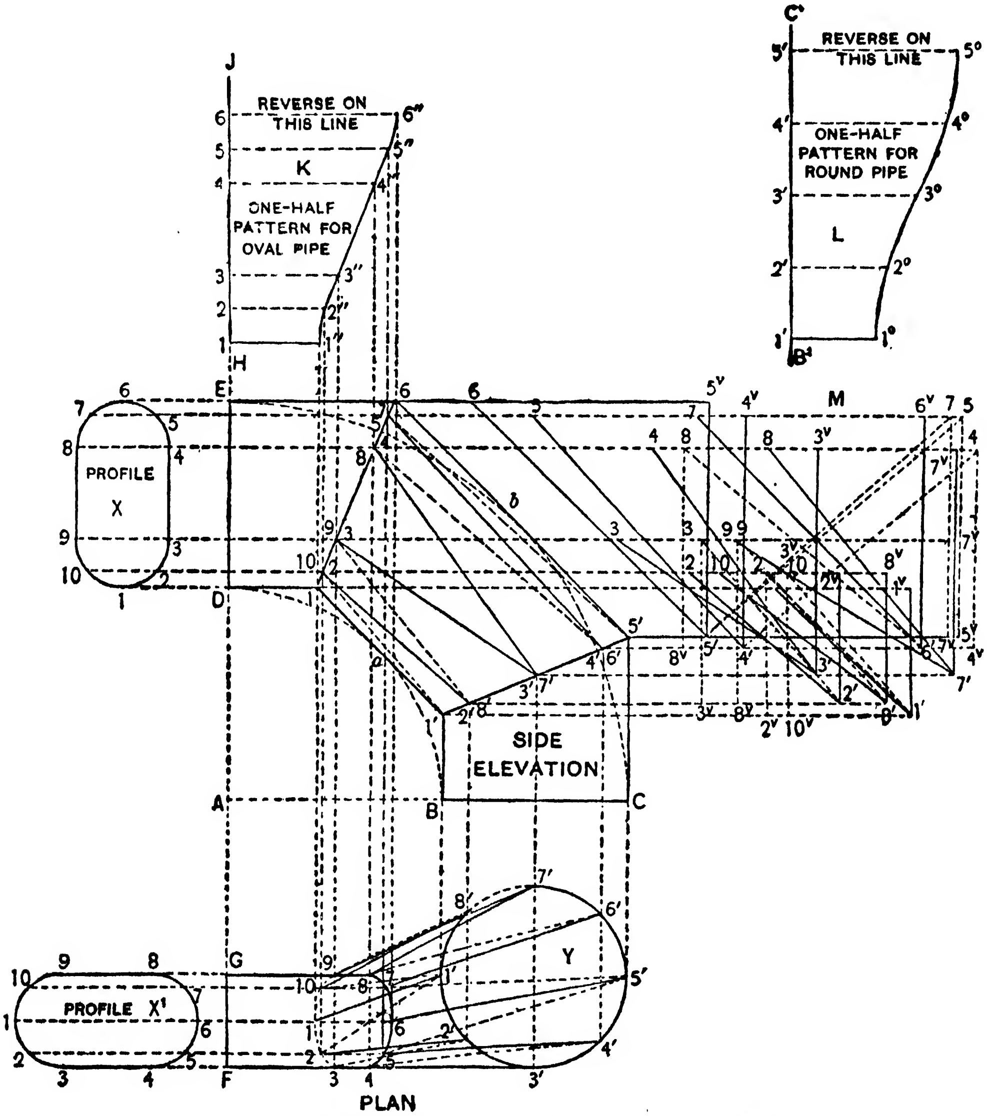


Fig. 7. Diagram of Triangles Showing True Lengths of Solid and Dotted Lines in Plan

angles to B^1 C^1 draw lines indefinitely as shown. Measuring from the line B C in the side elevation take the various projections to points 1′ to 5′ and place them on corresponding lines in L, measuring in each instance from the line B^1 C^1. A line traced through points will be the half pattern for the round pipe with seams at 1′ and 5′ in plan. If the full pattern is desired with a seam at 1′ in Y, then reverse the pattern L opposite the line 5′ 5°.

To obtain the pattern for the middle transition piece a correct plan view must first be drawn showing the horizontal section through the miter line 6 1 in elevation. From the point 3′ in the profile Y draw the tangent line 3′ F, which is intersected at F by a perpendicular line dropped from D in the side elevation. Take a tracing of the profile X and place it in the position shown by X^1 spacing it in the same size divisions as in X. Through the various intersections in X^1 draw horizontal lines, which intersect by vertical lines drawn from similar numbered intersections on the miter line 6 1 in elevation, thus obtaining points 1 to 10 in plan. A line traced through these intersections will represent the view looking down of the miter line 6 1 in elevation. Connect by solid lines 1 in the miter line to 1′ in the profile Y; 2 with 2′; 3 with 3′; 4 with 3′; 5 with 4′; 6 with 5′; 7 with 6′; 8 with 7′; 9 with 7′, and 10 with 8′. Draw dotted lines from 1′ to 2; 2′ to 3, and others as shown. Connect solid and dotted lines in elevation to correspond as shown.

From the various intersections on the miter lines 6 1 and 5′ 1′ in elevation, draw horizontal lines to the right indefinitely as shown, and proceed to construct the true lengths as follows: For example, to find the true length of the solid line 1 1′ in plan, take this distance and set it off on the horizontal line drawn from 1 on the miter line 6 1 in elevation as shown from 1 to 1^v; from 1^v draw the perpendicular line until it intersects the horizontal line drawn from 1′ on the miter line 1′ 5′ in elevation at 1′. Draw a line from 1 to 1′ in M, which will be the true length of 1 1′ in plan, or elevation. To find the true length of the dotted line 5 5′ in plan, set off this distance on the horizontal line drawn from 5′ in elevation, as shown from 5′ to 5^v, and from 5^v erect the vertical line until it intersects the horizontal line drawn from 5 in elevation at 5. Draw the dotted slant line 5 5′ in M, which is the true length of 5 5′ in plan or elevation. In this manner are all the true lengths of the solid and dotted lines found.

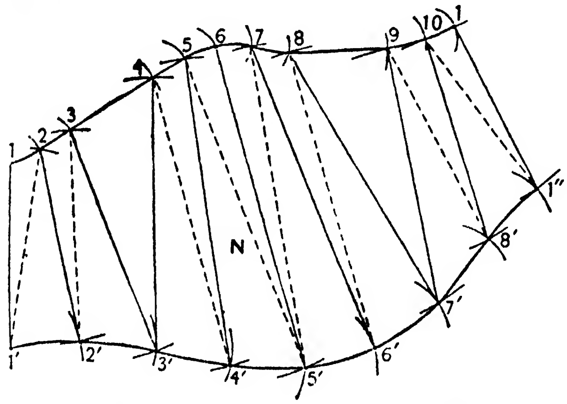


Fig. 8. Pattern for Transition Piece

In laying out the pattern for the transition piece no sections will be necessary on the miter lines 6 1 and 1′ 5′ in elevation, as the true distances along the miter lines will be taken from the miter cuts in diagrams K and L. The transition piece is developed as follows: Assuming that the seam is to come on 1 1′, in plan or elevation, then take the

true length of 1 1′ in M and place it as shown in N, Fig. 8. Now with 1″ 2″ in K as radius, and 1 in N as center, describe the arc 2, which intersect by an arc struck from 1′ as center and the true length of the dotted line 1′ 2 in M as radius. With 1° 2° in L as radius and 1′ in N as center, describe the arc 2′, which intersect by an arc struck from 2 as center and the true length of the solid line 2 2′ in M as radius. Proceed in this manner using alternately first the divisions in the miter cut in K, then the true lengths of the dotted slant lines in M; the divisions in the miter cut in L, then the true lengths of the solid slant lines in M, until the line 6 5′ in N has been obtained. Then using similar divisions in K and L (as the opposite halves of these patterns are similar) proceed to complete the pattern N to 1 1′. Trace a line through points thus obtained; then will 1 6 1 1″ 5′ 1′ be the full pattern for the transition piece.

PATTERN FOR LOCOMOTIVE CAB RAIN SHIELD

To lay out a pattern for a rain water shield to lie on top of the back end of a locomotive cab, its object being to protect the fireman while coaling the boiler, as shown by Fig. 9, it is suggested that if the locomotive is already built, a template be made of a combination of light sheet iron and strips of wood. This template must fit over the roof of the cab, thereby obtaining its outline. From this template the half end elevation of the cab can be drawn on paper. The shape of the upper edge of the shield may be drawn as fancy dictates.

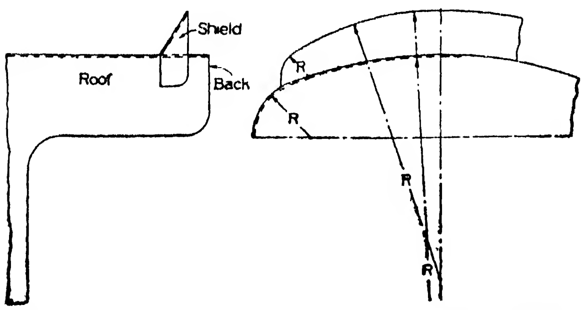


Fig. 9. Sketch Showing Locomotive Cab Rain Shield

For large drawings the sketching of a profile is, of course, accomplished most readily by the use of white chalk. After acquiring an outline that pleases, it can be drawn in with the lead pencil and the chalk brushed off. Of course, if the outline of the cab is to be ascertained from a scale drawing, it can be drawn by means of a trammel to the radii stipulated by the scale drawing; and it is not likely that these radii will be of a length to preclude trammels.

Having the end and side elevation as shown in Fig. 10, for the pattern, divide the outlines of the cab and shield into equal parts—the shield from point V 6. From V 6 to Z 6 divide again into equal spaces. Connect 1 to 1 and W, X and Y to Z 6. Also connect O R to 1, etc.; with dotted lines.

The true lengths of the hypotenuses of the system of triangles, of which these lines are the bases, are learned by drawing a horizontal line and erecting a perpendicular line to it, on which is placed the altitude of the triangles (constant in all) or the distance A B of side elevation. From B in the diagram of triangles, shown at the top of Fig. 10, and to the left, place the spaces in end elevation of Z 6 to Y, X, W and V 6, also 5 to 5, etc. And to the right the spaces O R to 1, etc.

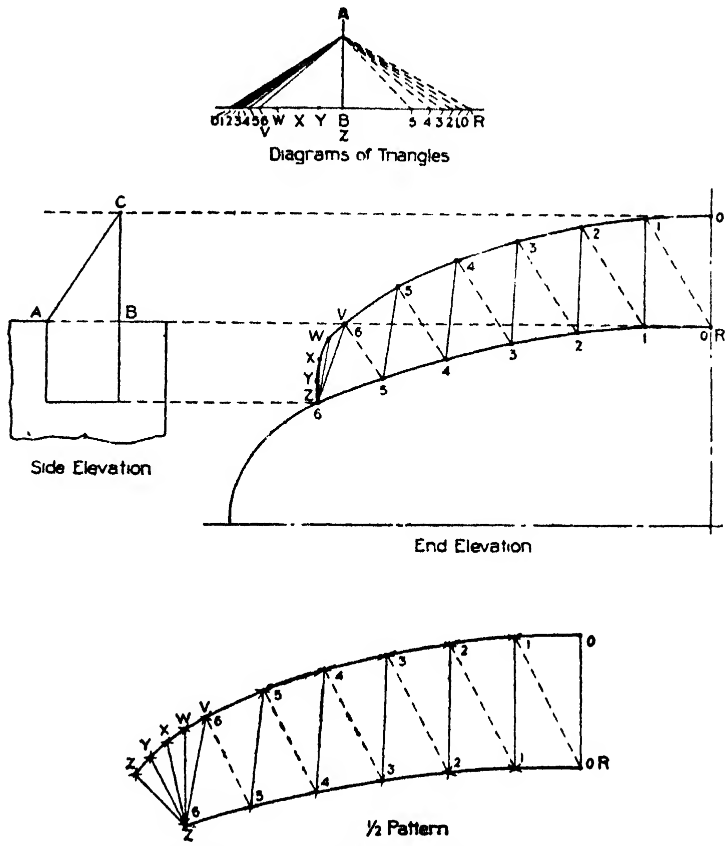


Fig. 10. Method of Obtaining Pattern for Rain Shield

The pattern is laid out by drawing any line of a length equal to 0 A of the diagram of triangles or A C of the side elevation; this line is indicated by 0 0 R of the half pattern. With the compasses set to 0 R A (0 R 1) of the diagram of dotted triangles, strike an arc, using the end of the line 0 R of the pattern for a center. This arc is intersected by one struck from 0 as a center and of a length coinciding with 0 1 of the outline of the shield. From this point of intersection, 1, as a center, strike an arc equal to 1 A of the diagram of solid triangles, which is intersected by an arc from 0 R equal to 0 R 1 of the outline of the cab roof, all as shown.

Continue in this fashion until V 6, Z 6 is obtained, then from Z 6 as a center strike arcs of the length of Z 6, W, Z 6, X, etc., of the diagram. With the dividers set to the space, in the end elevation, Z Y, etc., step off, beginning at V 6, this space on these arcs. A line traced through these points will give one half of the pattern.

In all probability this shield will be made of heavy iron, and therefore the thickness of the metal should be allowed for, proportionally, in the spaces, and a riveting edge along 0 R Z 6 and Z to Z 6.

BENDING HEAVY PLATE STEEL TO ARC OF A CIRCLE

In Fig. 11 the points A and B are the edges showing the flat parts usually present when heavy plates are passed through rollers of large size, if the edges are not first turned to the sweep of the circle desired by using a heavy wooden maul for the purpose. It is almost impossible to make a perfect curve by this method, even if done by skillful workmen. A method by which to accomplish the result desired, without the use of a maul or other treatment of the plate before it is formed in the rollers, is as follows: Place the steel plate to be rolled between two plates of a heavier gauge in the manner shown in Fig. 12. The three plates are shown in the position they bear to each other during the process of forming. The heavier plates must be of the length of the plate that is to be formed and of sufficient width to project beyond the side edges of it a distance somewhat greater than from the points A and B of the plate shown in Fig. 11 to the edges. When rolling the plates, the outside or heavier plates only will be flattened at the start and finish, while the center or lighter plate will form up perfect to the sweep to which the rolls are set.

Fig. 11. Showing Curve With Flat Ends

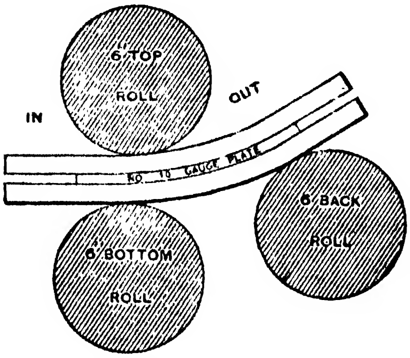


Fig. 12. Manner of Rolling the Plate to Circular Shape

MAKING AND ERECTING A SMOKESTACK

The subject of this article is an ordinary smokestack, and every operation necessary for its production and erection will be set forth in consecutive order exactly as it would be executed for a job of this kind.

As the metal man is seldom called upon to determine the size of such a stack the ratio of area and hight of flue to grate area, etc., will be passed over and it will be assumed that a 16-inch black iron stack, with oblong base 10 × 26 inches, is wanted, using No. 16 30 × 120-inch stock, and that it fits on a cast iron collar on top of the smoke box, extends through the boiler house roof, and is secured in a vertical position by three guy rods.

The first thing necessary is a sketch drawn to about ¾-inch scale, showing an elevation and plan of the stack, as in Figs. 13 and 14, upon which to mark the dimensions, etc., for ready reference and to show at a glance just what is to be done.

Next in order are full size details from which to develop the patterns. Therefore draw one-fourth of the plan of the base joint, as in Fig. 15. It is necessary to draw the full size oblong base profile longer than the finished size will be in order to allow for drawing in the metal at the outer ends to fit the vertical collar on the

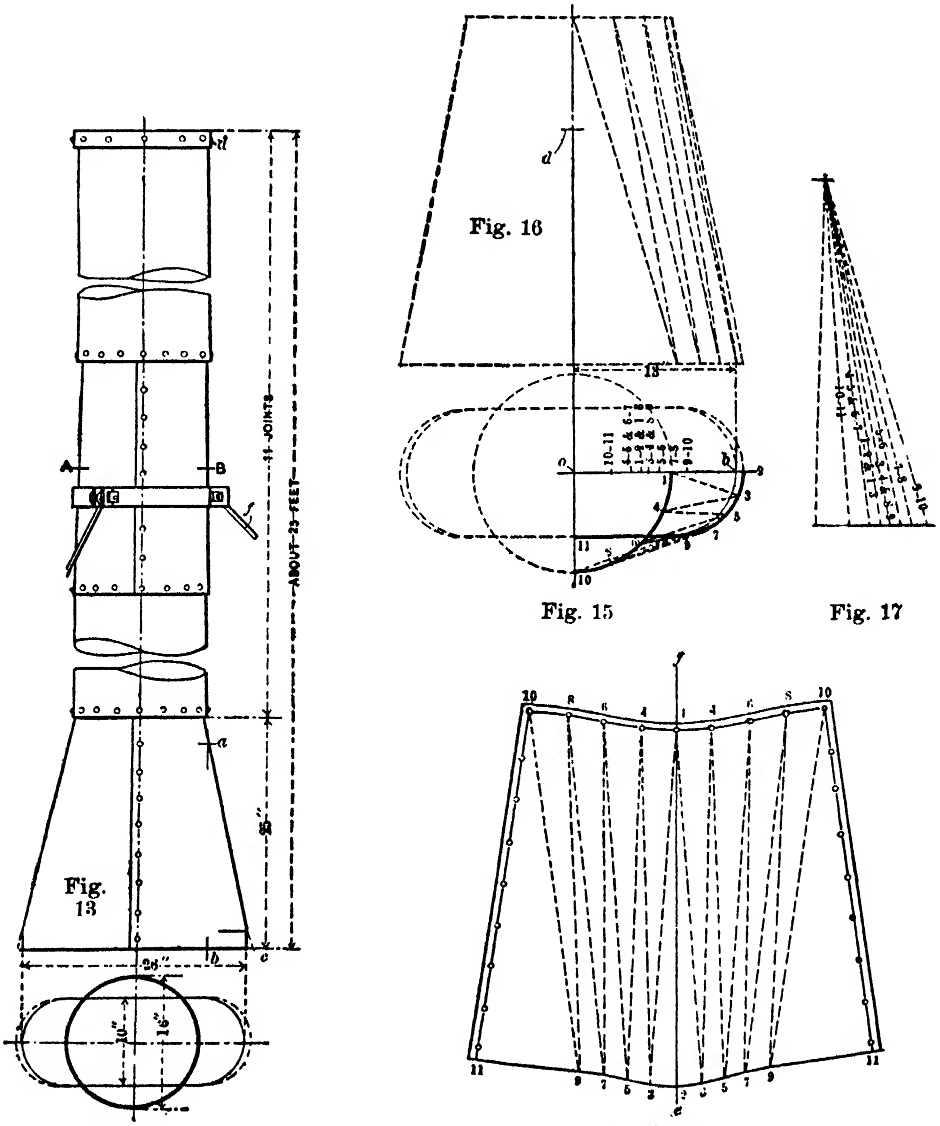


Fig. 14 Fig. 18

Laying out Pattern for the Base Section of a Smokestack

boiler. As Fig. 13 has been drawn to scale, this difference is quickest ascertained by setting off the full hight of the boiler collar from the bottom of Fig. 13, intersecting the sloping side of the base joint, as at *a*. From *a* drop a perpendicular to the base line, as *a b*; then *b* 2 of Fig. 15 should equal *b c* of Fig. 13. This only applies of course where the flare of the base and hight of collar are not too great to

admit of drawing in the metal sufficiently, as otherwise it is necessary to provide the base joint with a separate straight collar piece to fit over the boiler collar.

From *o* 2 in Fig. 15 draw a perpendicular, *o d*, equal to the straight hight of the base joint. (All pattern lines are net butt or rivet lines, and all laps are added to patterns afterward.) Space the top and bottom profiles of the base joint, as indicated in Fig. 15 by 1, 4, 6, 8, 10 and 2, 3, 5, 7, 9, 11, respectively, and from the point *o* set off on *o* 2 the several distances 1 2, 1 3, 3 4, 4 5, etc., as indicated. The dotted lines of Figs. 15, 16, 17 and 18 indicate the usual method of developing the pattern by triangulation, but while it is necessary to keep the lines in mind it is unnecessary to actually draw any of the dotted triangulation lines, as the solid lines and points thereon are all that are needed to give spacings or dimensions.

To develop the half pattern of the base joint, proceed as indicated by Fig. 18. The spacings 1 2, 1 3, 3 4, etc., of Fig. 18 of course equal the distances from corresponding points on *o* 2 to *d*, Fig. 15, the spacings 2, 3, 5, 7, 9, 11 of Fig. 18 equal corresponding spacings in the oblong profile of the base, Fig. 15, and spacings 1, 4, 6, 8, 10 of Fig. 18 equal like spacings in top or round end of Fig. 15.

The rivets in a stack of this size and gauge should be about 10 pound in size, spaced about 2 inches apart. The holes should be about 1-16 inch larger than the rivets to allow for inaccurate matching, and the rivets should be of sufficient length to allow for enough upsetting to completely fill the holes and provide good heads.

The next step is the development of the pattern of the round joints. Each joint is a frustum of a cone, being so tapered that the bottom of each joint fits over the top of the one below it, at the same time maintaining a uniform general diameter throughout the round portion of the stack.

As the angle of taper is so slight and the converging radius is consequently so great as to make it inconvenient, if not impractical, to describe the pattern as frustum patterns are usually struck—from a center—it is necessary to describe the arcs of the pattern without recourse to a center. Fig. 19 shows the proportionate shape of the pattern, but in order to more clearly illustrate the principles underlying its development the taper of the joint and consequently the curve of pattern arcs are exaggerated, as indicated in Figs. 20, 21 and 22, the actual taper necessary being about 3-16 inch, or the proportion shown in Fig. 13. In Fig. 20 *a c d f* represents an elevation of a joint turned upside down; *e b* is the center line and represents the straight hight; *a c* the diameter of the large end and *f d* the diameter of the small end. The arc *a g c* is developed as follows:

With the dividers locate *j* so that its perpendicular distance from line *d c* will equal its distance from *b*; from *d c*, perpendicularly through *j*, intersect center line,

establishing g; draw the straight line $g\ c$; draw a line through j across and perpendicular to $g\ c$; locate k, so that its perpendicular distance from $d\ c$ will equal its distance from j; from $d\ c$, perpendicularly through k intersect j J, establishing l; draw $l\ c$; through k draw a line across and perpendicular to $l\ c$; locate o so that its perpendicular distance from $d\ c$ will equal its distance from m; from $d\ c$, perpendicularly through q, intersect $k\ m$, establishing p; draw and bisect $a\ g$; draw a per-

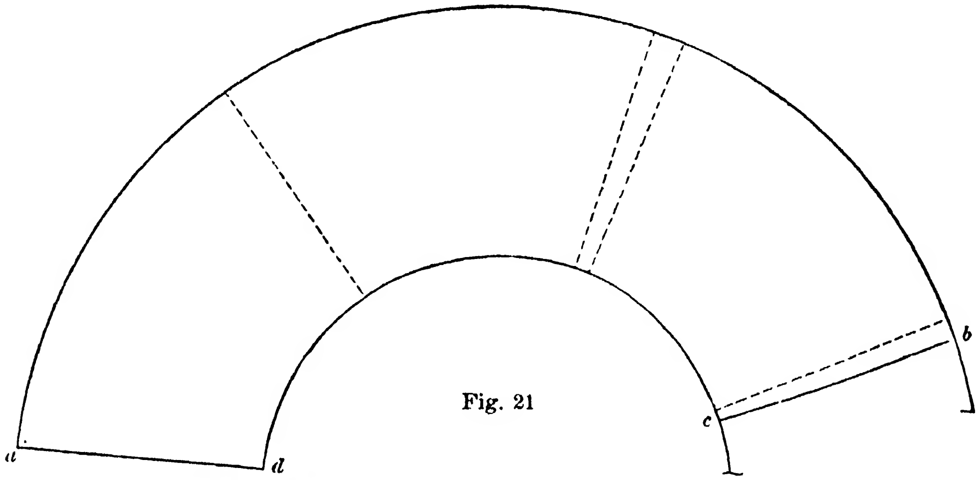
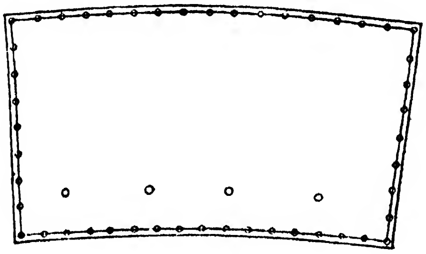


Fig. 21



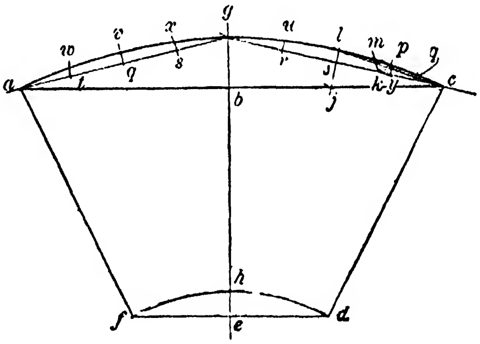


Fig. 19. Fig. 20.
Shape and Development of Pattern of Base Section of Smokestack

pendicular through point of bisection q; make $q\ v$ equal to $j\ l$; with a radius equal to J p strike arcs on each side of and with J and q as centers, intersecting $g\ c$ and $g\ a$; from lines $g\ c$ and $g\ a$ set off on these arcs the distance $y\ p$, establishing u, x and w. A line traced through $a\ w\ v\ x\ g\ u\ l\ p\ c$ is the true curve of the large end of the pattern. The curve of the small end is obtained by striking arcs from the large curve with radius equal to $a\ f$ or $c\ d$ and tracing a line through the same.

There is now a trifle less that one-third of the pattern. The full size stretchout is obtained by starting from $a\ d$ and shifting and duplicating, as indicated by Fig. 21. The pattern piece should be shifted three times. Obtain the circumference of the large end of the pipe by multiplying its diameter by 3.1416, and measure it off

on *a b*, the larger curve of the pattern; now place the pattern piece on the pattern with its outer curved edge coincident with the outer curve of the pattern and its straight edge at the circumference indicating point and scribe the line *b c*. Then *a b c d* is the net butt or rivet line of the pattern, to which a lap of 5/8 inch must be added all around.

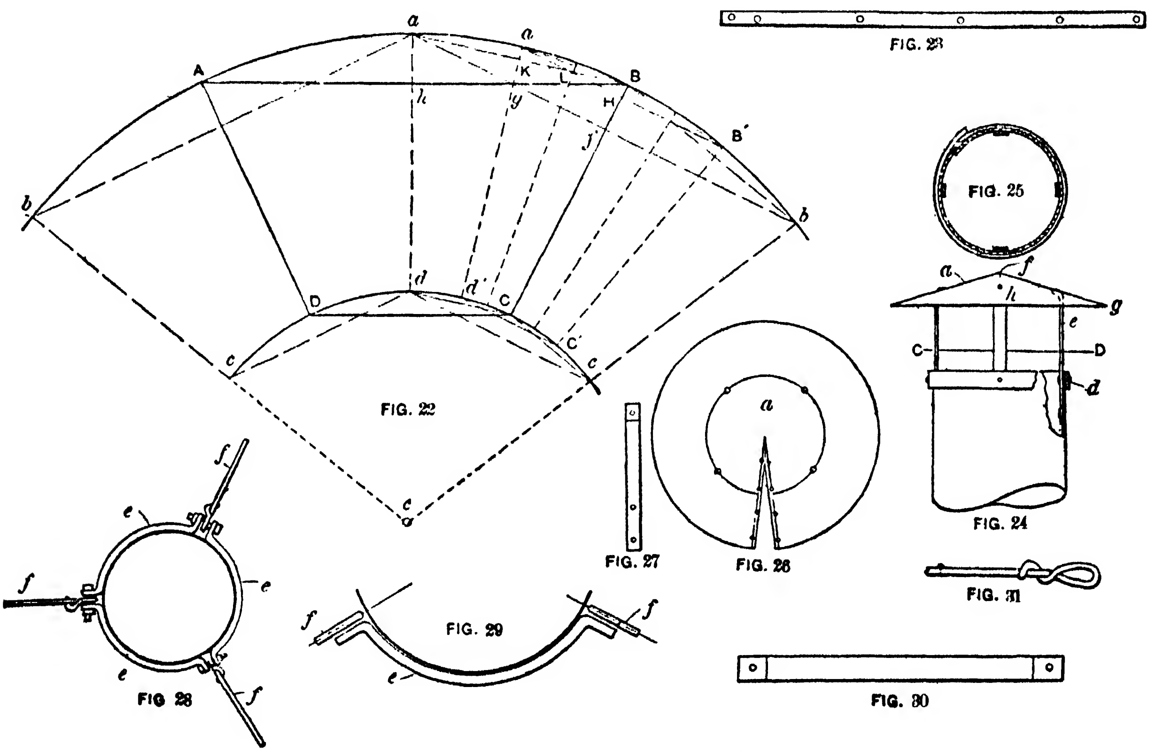
Fig. 22 is not used in practice, but is shown here merely to make clear the principles by which the arc *a g c* of pattern piece, Fig. 20, is developed. It will be seen that when A B C D is revolved around center *e* to the position of *a b c d*, or until its center line is where its side line was, *f g* and *h g* are equal and that *h a* equals the hight of the arc of which A B is the chord. The principle holds good with any radius or size of cone section.

Fig. 23 is the pattern of top band *d*, Fig. 13, which is laid off directly on the 2 × 1/4-inch band iron. It will be seen that only alternate rivet holes are used, and that the lap of the band and the pipe seam are dodged by one rivet spacing. Fig. 24 shows the stack provided with a cap, the diameter of which is one and two-thirds and the hight one-quarter those of the stack. The distance from the top of the stack to the lower edge of the cap should equal one-half the diameter of the stack. When a cap is used the band *d* need only be 2 × 1/8 inch, riveted only at the braces *e*. These braces should extend down into the pipe about 6 inches and be secured with a second rivet each. Fig. 25 is a section on C D of Fig. 24 and shows how the braces, seam in pipe and lap of band should dodge each other. Fig. 26 is a pattern of the cap, which is quickest obtained by striking a circle with radius equal to *f g*, Fig. 24, out of which take six times the difference between *f g* and *h g*, Fig. 24. To this should be added the laps. Space off rivet holes for braces *e*, as indicated.

Fig. 27 shows a pattern of 1 1/2 × 1/4-inch braces, *e*. Fig. 28 shows the 2 × 3/8-inch guide rod strap, made in three pieces, secured together by 1/2-inch bolts, which also pass through eyes formed in the ends of the 3/8-inch guide rods. It is only necessary to lay out one-third of Fig. 28 full size to develop the straps (see Fig. 29.) Fig. 30 is a pattern of one piece of the strap. Fig. 31 shows how the eye should be formed in the guide rods.

If the punch with which the rivet holes are to be made is provided with a center point the rivet spacings of the pattern should be prick marked, or centered, only, and the material be likewise pricked, or centered, from the pattern, but otherwise the rivet holes in pattern should be accurately made with a punch about 1-16 inch larger than the punch that will be used on the material and the holes carefully scribed onto the work. Thus the thickness of scribe is allowed for, so that the circles are about the size of the punch, making centering easier.

After cutting, punching and forming in the machine rolls, the next step is to rivet the longitudinal seams in each joint separately. Next assemble the stack by riveting a round joint to the base joint; then add round joints until the entire stack is put together in one piece, which is possible in this case, the length being only about 25 feet and weight not exceeding 300 pounds. In riveting together the joints of such a stack a straight piece of railroad iron, firmly secured in a perfectly horizontal position and projecting about 5 feet into the stack, makes a good mandrel. Such a mandrel, together with an overhead track carrying a roller from which is



Patterns for Minor Parts of a Smokestack

suspended a chain tackle for supporting the stack in a horizontal position, makes it comparatively easy to rivet the joints together quickly and accurately.

In a job of this kind the accuracy of the patterns entirely governs the facility with which the work can be put together, thus it is essential that the pattern be made absolutely correct in every particular before any material is marked out. When the stack is dry, after receiving two coats of black asphaltum paint, the simplest way to set it up is as follows:

Provide one good man with three strong helpers, plenty of ¾-inch guide rope, a block and tackle hoist and two strong 18-foot ladders. After delivery to building the four men can hoist the stack on the roof by hand; next attach the strap and

guide rods and lay the stack over the hole in the roof, with the hole about midway of the stack. Now lay the ladders one on top of the other, tie the upper ends together and secure the tackle and two guide ropes thereto. Raise the ladders to a vertical position and spread the bottoms about 8 feet apart, locating them so that the tackle will hang vertically over one side of the roof opening. Secure the ladders in this lean-to upright position with the two guide ropes tied to the most convenient hitchings. Wind a rope several times around the stack just above the middle, form a slip noose and hang on the tackle. Hoist the stack until the lower end can be inserted and lowered through the roof opening and connected with the boiler. Now permanently secure the guide rods to convenient hitchings (previously provided), ascend one of the ladders and disengage the rope from the stack, lower the ladders and make the connection between the roof and stack, as described.

FACILITIES FOR WORKING WROUGHT IRON

A majority of the shops that do general sheet metal work find it necessary to use and work a considerable quantity of bar and heavy sheet iron, but comparatively few are adequately equipped for such work. The average equipment consists of a small forge, a vise, a brace bender, a hand punch, shear and drill, and, possibly, a very small shallow throated power punch, all in more or less dilapidated condition, and with the forge so located as to be inaccessible for heating any other part than the ends of bars, etc.

This general failure to provide adequate facilities for economically turning out this part of the work may be accounted for by the assumption that this branch is not important enough to justify any considerable investment in machines or floor space. It has been found that one large deep throated combination power punch and shear, with plenty of dies, benders, shears, etc., is worth more than any number of small inadequate tools without proper dies.

Some concerns make the mistake of spending several hundred dollars for a machine of ample power and throat capacity, and then fail to get all the attachments that can be used to advantage with it. In one instance a certain concern took a contract that required the punching of a considerable number of 1½-inch holes through ⅛-inch metal, and while they had a machine of sufficient capacity, the 1½-inch punch and die were lacking, and, rather than spend the price of the same, they chewed out the holes by using a small punch and punching a circular row of holes, and then filed up the jagged edges, which cost more in extra labor than the

new punch, and did not produce accurate work. In another case a party made ⅜-inch square holes by punching ⅜-inch round holes and squaring with a file.

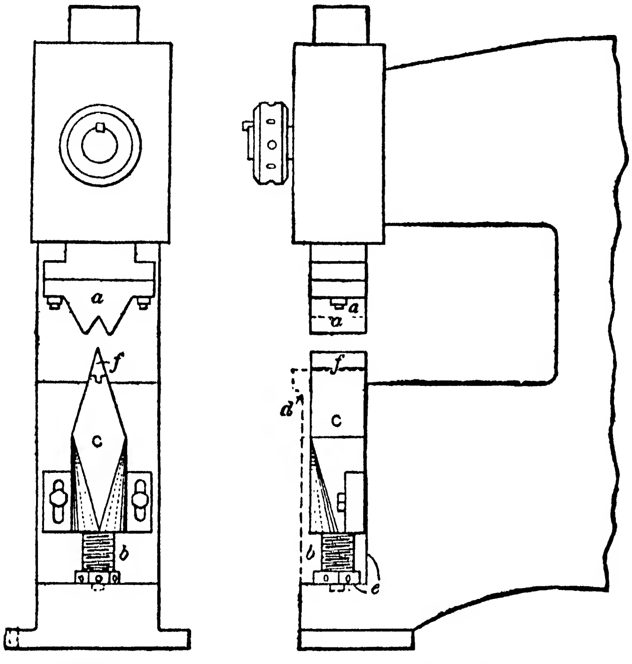


Fig. 33. Fig. 32.
An Ideal Machine for Working Wrought Iron

In both of these cases the parties argued that they had such little use for such dies that it would not pay to buy or make them. At the same time they spent their cost in extra labor, which would have been saved if the dies had been secured and used. Moreover, they would have been on hand ready for any more of such work. It pays to have every attachment that can be used to any advantage on any machine.

For a shop doing general cornice work a machine of this kind should have a capacity of cutting 3×3×¼-inch angle iron, which strength would also meet any other shearing, punching and bending requirements in the construction of roofs, curbing and any miscellaneous structural framing likely to be encountered by the cornice makers. The principal attachments and tools needed are: Bar shears, with gauge; splitting shears, with gauge; round iron shears; angle iron shears; punches, closely graduated from the largest to the smallest ever used, taking care to keep on hand several sets of each size of the small punches and those sizes most used, and any special punch such as square, oblong, slot shaped, etc., likely to be needed.

A special bending tool that has been found extremely useful in connection with a power punch and shear is shown in the illustration, Fig. 32, which is a broken side view of the machine, showing the bender in position, and Fig. 33, which is a face view of the machine and bender. In order to use this tool the dotted line portion *d* of the lower jaw, or bed, of the machine must be removable, so that the bender can be placed directly under the plunger, or vertical acting head, to which is bolted the upper inverted V-shaped die *a*, made of cast iron. The lower die consists of two members—*b* and *c*. *b* is a stud about 2½ inches in diameter, hexagon shaped for about 1 inch at its lower end, which rests on the

ledge, from which the block *d* is removed, and is provided with a short tenon which sockets into the ledge to keep the stud in place. *C* is of cast iron, into which the stud *b* is threaded about 8 inches. It is provided with slotted flanges on each side for bolting to the face of the machine bed, is tapered off in wedge shape at its upper end and is finished with a hatchet shaped steel point, *f*.

It will be seen that by turning the stud *b* the member *c* can be raised or lowered, in order to produce any desired angle in bending, in the same way that one member of a vertical acting cornice brake can be adjusted to produce any angle when forming molded work. This bender bears the same relation to wrought iron work, especially cornice braces, as compared to an ordinary brace bender, as the upright cornice brake bears to cornice moldings, as compared to a hand brake.

PATTERN FOR SIDE OF BOILER BREECHING

This problem is of frequent occurrence and the following is an explanation of how to lay out the pattern for the side of the breeching against which the clean out door closes, opposite the flues in a power boiler. Fig. 34 shows the boiler with the breeching which leads to the smoke stack in position. In Fig. 35, O P in the front elevation represents the circumference of the boiler, F B D the breeching and A B C D E the clean out door, while in the side elevation E′ E 4 4′ represents the side of the breeching, which is represented in the front elevation by A B C D E. As the two halves are the same, it will be only necessary to find the pattern for the one half, C D E.

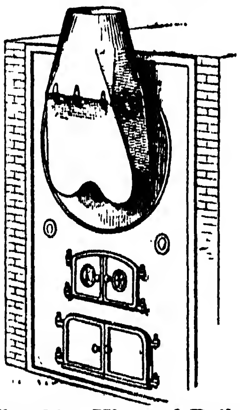


Fig. 34. View of Boiler and Breeching

Divide the curved part of the half front elevation C D E into a number of equal parts, as shown by the small figures. From these points and from the point E draw horizontal lines into the side elevation, intersecting the clean out door and the side of the boiler, as shown by similar letters and numbered points. Then draw in Fig. 36 the stretchout line C E, on which lay off the stretchout of C D E in Fig. 35 in front elevation, as indicated by similar letters and figures on the stretchout line in Fig. 36. Through these points draw lines perpendicular to C E, send on the lay off the distances as obtained in the similarly numbered letters in

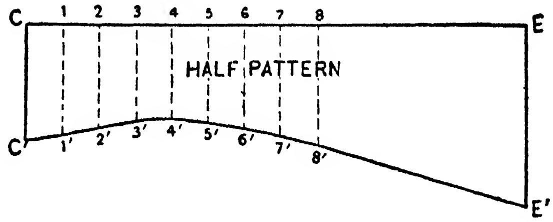


Fig. 36. Laying Out the Pattern

the side elevation. Draw lines through the points thus obtained. Then will C E E′ C′ be the half pattern desired.

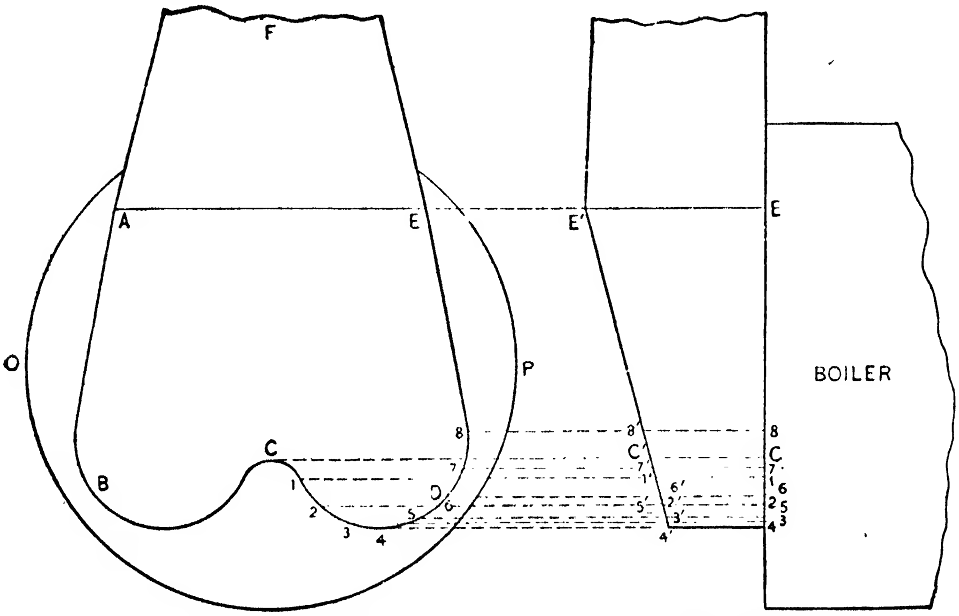


Fig. 35. Obtaining the Developing Lines

PATTERN FOR A PIPE BRANCH WITH ITS TWO PARTS JOINED

Of the many problems submitted for solution in the pipe work, this is worthy of especial consideration, by reason of it requiring the seams to be along the lines *a b* and *c d* of Fig. 37 and to have the pattern in halves—one half of F and one half of E in one piece. This condition as imposed does not complicate the pattern; on the contrary it simplifies it and what is more important it allows of great ease in uniting the parts together. In the first figure are reproduced the inquirer's sketches as shown by the heavy lines, and for a clear conception of the article the views were drawn complete. The developing of the patterns for this branch would not be extraordinary, for part F is simply the frustum of a right cone intersected by a scalene cone E, were it not that it is required that the seams be as aforesaid. As the pattern line at the intersection would ordinarily be a curve, these two halves of the pattern could not then be in one piece; hence the intersecting plane, the

edge of which is represented by the line *f g*, Fig. 37, must be bounded by straight lines (as shown fore-shortened by the dotted triangle *h, i, j*, of the front elevation), which will give a straight joining line for the two parts of the pattern.

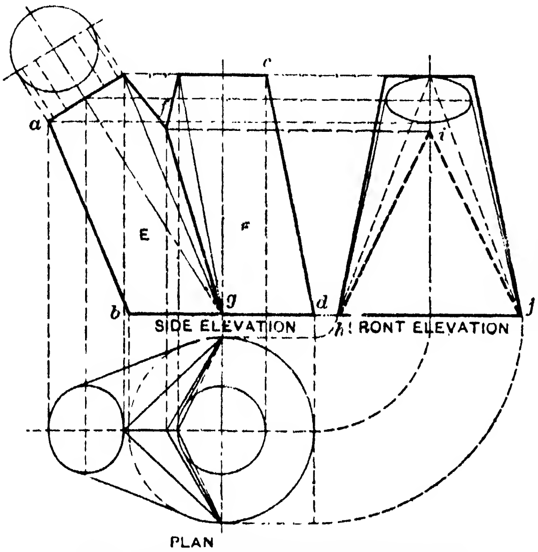


Fig. 37. The Problem as Submitted

The problem thus rests as a geometrical figure with a contour composed of various shapes; the portion of F, Fig. 38, from 11 to 14 and 18 to 21 is part of a right cone; 18 and 8 to 11 is a curved surface the elements of which diverge from 18 and there is a flat plane, 18 and B to 8. The same can be said of E except that the portions from 1 to 4 and 15 to 18 are parts of a scalene cone.

The usual method of developing the surface of the shapes stated will not be used, such as finding the outline of the conical surface by radial lines, but by triangulation throughout; therefore, draw the side elevation as in Fig. 38 with one half of the profiles placed as shown. Divide these profiles into a like number of spaces and connect 15 to 18 and 1 to 4 with solid and dotted lines and 4 to 7 and 18 with solid lines. Repeat for F.

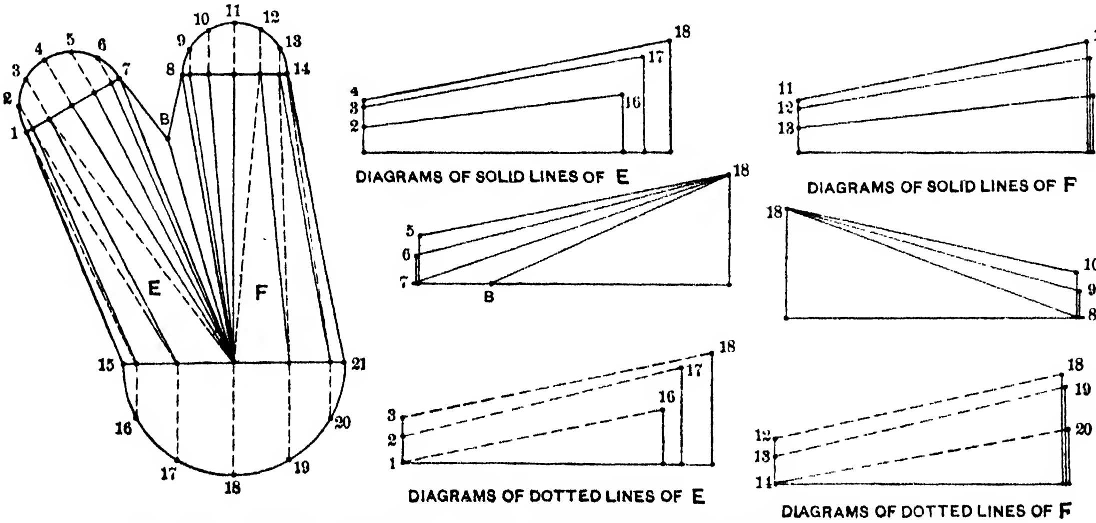


Fig. 38. Elevation, Profiles and Diagrams in Obtaining Pattern for Pipe Branch

The ascertaining of the true length of these lines is accomplished by a system of diagrams which if followed carefully step by step should be self-explanatory. That is, the lengths of the solid and dotted lines as given by the side elevation are

placed on the base line and from these points perpendiculars are erected of a length coinciding with those of the profiles. The lines connecting correct points will be the exact length of the lines shown in the side elevation, as 17 3 of E is true on 17 3 of the diagram of solid lines.

Since the lines 1 15 and 14 21 are indicated in their true lengths in the side elevation and as the seams are wanted on those lines the pattern is started by drawing anywhere a line equal to 1 15, as in Fig. 39, and from point 1 with compasses set to 1 16 of diagram of dotted lines strike small arc and from point 15 with bow dividers set to the space 15 16 prick off on the line just drawn, the point 16; and so on to 4 18. Then from 18, the various lines of the diagram for this part are struck and then stepped off with the bow dividers adjusted to 1 2. Likewise B and 8 are struck from 18 and the space 7 to B to 8 of the elevation set on these arcs. The surface F is obtained in a similar way.

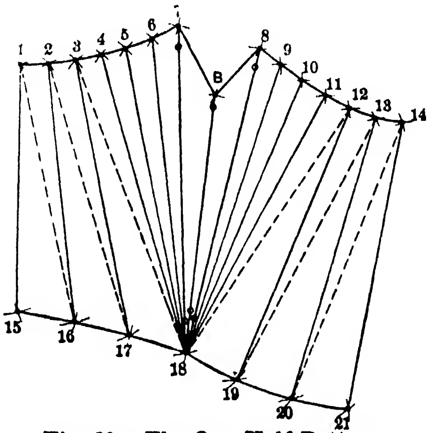


Fig. 39. The One Half Pattern

When forming up this pattern slight bends are made, in the same direction, one line 18 to 7, another 18 to 8 and the third 18 to B, being reverse of the curved parts.

ASCERTAINING MITER LINES OF ELBOWS IN DISCHARGE PIPING OF CONVEYOR SYSTEM

One of the frequent requests received, is that for finding the true angle in a change in direction in piping. In Fig. 40 is reproduced a sketch submitted by a correspondent, for the developing of the miter line and pattern for the elbow of conveyor piping at the junction of pipes A and B at C. He also desired information as how to develop the cut of the openings of the corrugated window fills. To make it of utmost interest to the other readers, all miter lines and openings are here developed.

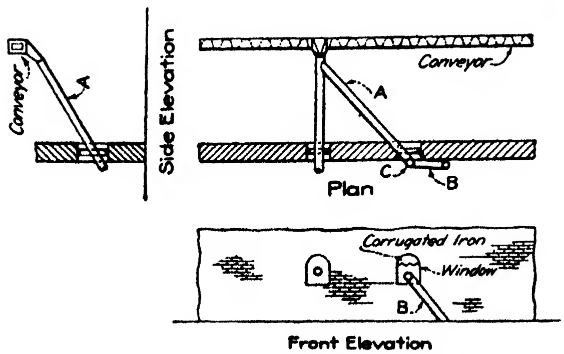


Fig. 40. Problem Submitted by Correspondent

The first essential in laying out work of this class is correct measurements of the building, giving all data, such as the hight of ceiling, distance conveyor is from

the windows or wall and the like. A plan and oftentimes two elevations are drawn to a scale. In these various views the piping may be sketched in, as indicated in Fig. 40.

With this information at hand, and knowing that in problems of this sort the form of the object or objects is neglected for the time being, and only the center or rather axial line utilized as working material.

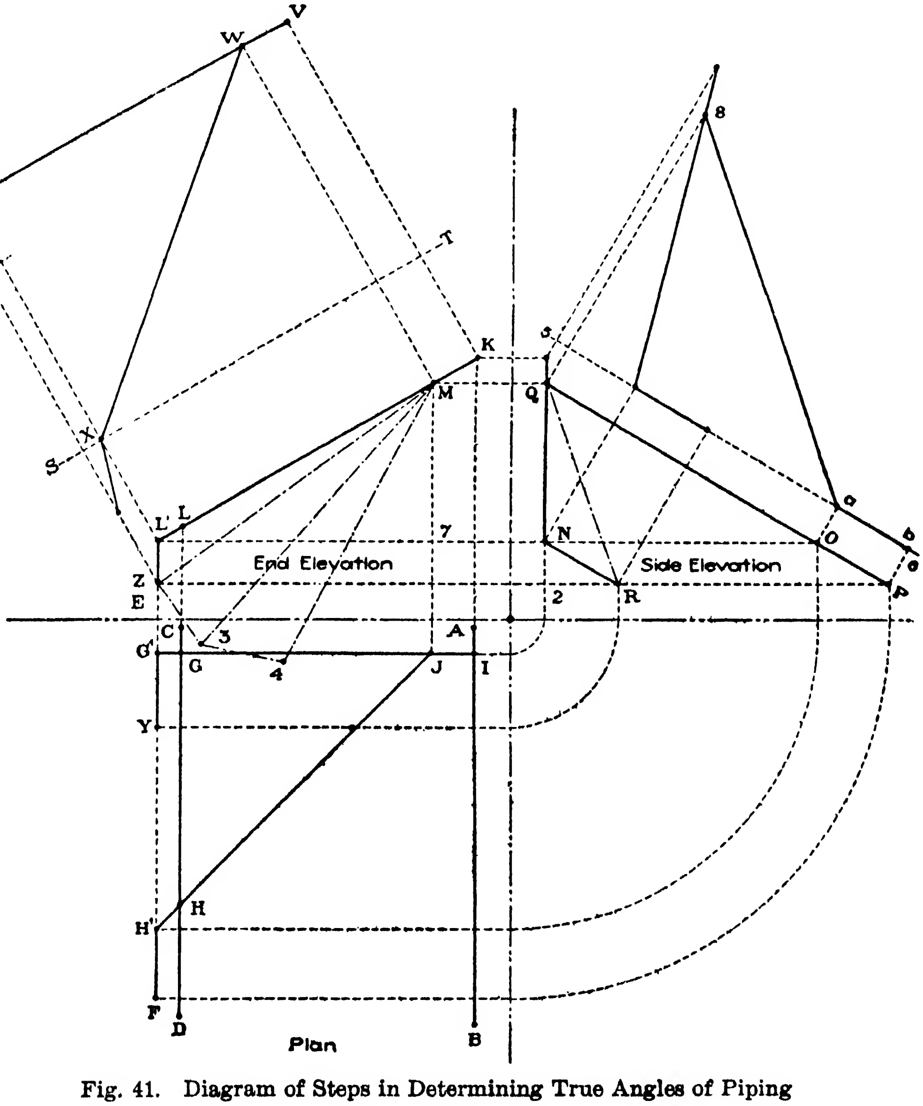


Fig. 41. Diagram of Steps in Determining True Angles of Piping

Referring to Fig. 41, therefore, a line A B representing the conveyor in plan is drawn. As the conveyor is parallel to the wall through which the piping passes, another line as C D represents this wall. This line will not be the axial line of the oblique pipe, inasmuch as the diameter of the pipe is to be taken into account. Accordingly, another parallel line the distance away from the wall equal to the

radius of the pipe is drawn, as E F. From the data the centers of the windows G and H are located on line C D, also point I on the conveyor line. A line drawn through points I and G from A B to E F will be the axial line of one run of piping. The point of intersection of the other run of piping with this is fixed where required, as at J. From J then, through H to line E F, draw a line to be the axial line of the run of piping labelled A in Fig. 40.

The line of the conveyor in the end elevation is now indicated by the dot K. This is to be the hight above window openings as called for by the data. The window openings are shown by the dot L. The piping is indicated by the axial line in elevation from K to L′ and the point of intersection by M.

A side elevation is projected to the right, as shown, in which N and O are the center points of the elbows, and O P the line of piping designated as B in Fig. 40. In this case the slope of O P is such as to have the line of piping O P lie in the same plane in this side elevation to the line of piping O Q, which is H′ J in the plan; it is to be remembered that this slope is governed in practice by the data. The correspondent does not state how the piping G J of Fig. 41 turns after passing out the window, but for enhancement of this article it is assumed that it passes down the side of the wall, as N R parallel to O P.

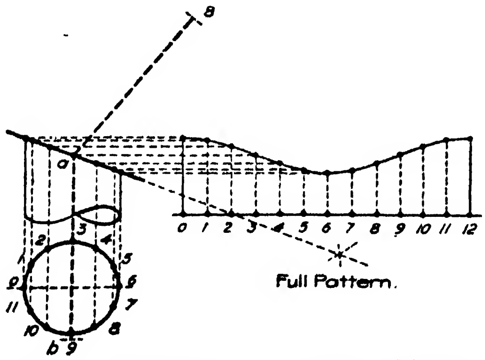


Fig. 42. Development of Pattern of Elbow C in Fig. 40

With this much of the elevations and plan the true angle of the intersection of the two lines of piping can be ascertained, though again he does not require this. Before going any further, it is well to remark that a practical suggestion is not to branch two lines of pipe in the manner he indicates in Fig. 40. Instead, a fitting should be made which is a transition from the shape of the conveyor to an ordinary fork about as sketched in Fig. 43 in the upper corner of the illustration.

Parallel to line L M K draw a line as S T; from this the distance G H draw another parallel line as U V. Project the points L′ M and K to these lines as shown. Then U V will be the true length of G^1 I and point W the true position of the point of intersection of the two lines of piping. Then W X will be the true length of line H^1 J. Also U W X is the true angle of the intersection at W.

For determining the angles of two lines not shown true in any view, as the angle J G^1 Y in the plan of Fig. 41, an expeditious method would be to assume that

M L′ Z (or Q N R) is a triangle. Granting this much, the next operation would be to lay this triangle flat; that is, view the plane in which the triangle lies at right angles. This can be most readily accomplished by first learning the exact length of side of the triangle M Z. To do this, erect a line at right angles to line Z M and from Z the length of 2 R, as Z 3. Knowing that N R lies in a plane viewed at right angles, and is therefore its true length, the next step would be to swing an arc of the radius of this length from 3. Again, knowing that L′ M is the true length of the line Q N (or G[1] J) an arc of this length as radius is swung from M to intersect the first arc, establishing point 4. Hence, M 3 4 is a full view of the mentioned triangle and 3 4 the true angle of J G[1] Y.

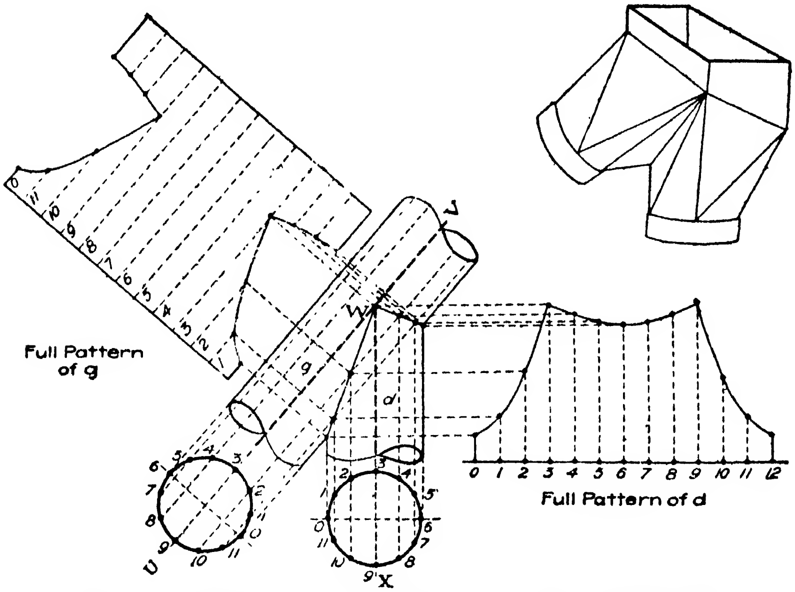


Fig. 43. Development of Pattern for Two Pipe Connections and Suggested Alternate

Another method of finding the true angle, that of J H[1] F, may be indicated by projecting an oblique plan from the side elevation in this manner: Parallel to Q P draw a line at 5 6. Project the points Q O P to this line, continuing the line from Q indefinitely. Take the distance L′ 7 in the end elevation and place it on the line from Q, giving point 8. Where lines from O and P cut line 5 6 will be called *a* and *b*; and a line drawn from 8 to *a* and *b* will be a true view of J H[1] F and, of course, the desired true angle.

For the pattern of an elbow of this angle, transfer line 8 *a b*, as in Fig. 42. The rest of the procedure is of such everyday occurrence that further explanation is unwarranted. Similarly, the procedure for the branch is as shown in Fig. 43.

For the openings in the corrugated window fills, a suggestion is that the opening be laid out on a flat piece of metal, then this template laid on the corrugated iron at the correct position and the opening scribed thereon. In Fig. 44 the axial line L M K in Fig. 41 is reproduced, also the line L M. And in the plan, the axial line H J in Fig. 41 is represented by H J in Fig. 44, together with line C D. For the opening at G, the profile of the pipe S is divided into spaces and the usual

parallel lines drawn to line L′ Z, thence horizontally to the left indefinitely. Erect any vertical center line as X T and from both sides of this line place the distances of the profile; for instance, 6 O in the profile is 6^1 O^1 in the template; and so on, realizing the elliptical figure as shown for the opening.

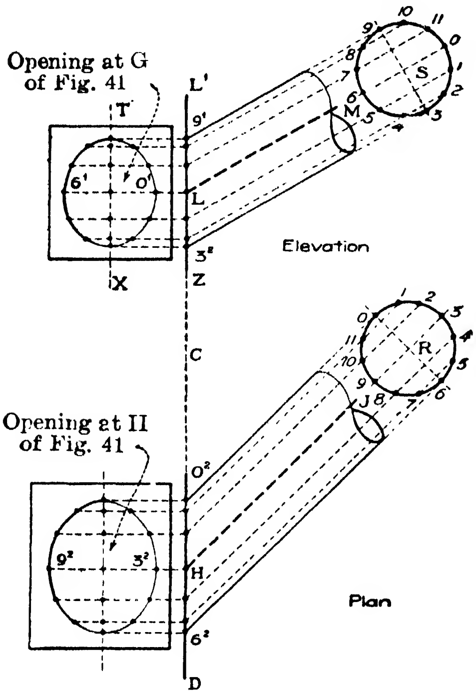


Fig. 44. Method of Cutting Opening in Window Filling

In like manner divide profile R and project lines to line C D, thence to the left and vertical center line erected. Instead of taking the distances from profile R as was done for S, it is to be remembered that line H J is at an angle to C D, both in elevation and plan. In consequence, while the spaces, as O 6 of profile, are each at O^2 6^2, the distance 9 3 is greater. Imagine that line H J is the edge line of a plane as wide as 9 3 in profile R. This plane in elevation is 9 3 in profile S, and would be cut obliquely at L^1 Z as 9^1 3^1. So much decided, this distance is carried to the vertical line for the opening at H, as 9^2 3^2. The process as outlined is repeated until the points for the elliptical opening are obtained as shown in the illustration, Fig. 44.

A BOILER FLUE CONNECTION PROBLEM

This problem deals with a connection between the smoke outlet of a boiler and the flue hole in a chimney at a higher level and offset from the position of the boiler. The furnace collar is of the oval shape, and in a relatively short distance the smoke connection is to be changed from the oval to the round in order to fit into the chimney. As explained in the following discussion, the idea has been not to treat the question as one to be worked out by a special application of sheet metal pattern drafting, but to attempt to make the offset with the use of elbows or parts of elbows, such as one is likely to have in stock for general pipe requirements.

In preparing the answer to the foregoing inquiry the author had in mind, as a result of a considerable experience in these lines, that no employer will allow his foreman the time to lay out fancy fittings, by reason of his inability to ask his customer a price to cover the time to lay out and make and likewise connect smoke

pipe built on such lines. Hence, due thought was given to describe everyday practice.

The sketch, Fig. 45, shows a boiler with an oval $9\frac{1}{2} \times 14\frac{1}{2}$-in. collar connecting to a 12-in. round flue opening, which is a given hight above the collar and to the right of it when viewed from the front of the boiler.

After the boiler is set in its permanent position the measurements can be taken in this manner: With a stick held level and in the center of the boiler collar, also square with the face of the chimney and of a length to touch the chimney (assuming that the boiler is set square with it), establish the point *d* in Fig. 45. Drawing a level line from this point on the chimney to a line dropped plumb from the center of the flue gives the offset to the right and the vertical rise from the boiler collar to the flue opening. These measurements are jotted down in a sketch like Fig. 45, not forgetting the distance the boiler is from the chimney on a line perpendicular with the face of the chimney. The boiler collar is measured for both diameters and the girth found by winding a thin strip of sheet metal around the outside of the collar. For a positive shape of this opening an ellipse is not drawn geometrically, for who knows if the collar of the boiler was so laid out, but a piece of paper is held against the collar and the hand rubbed over it; the collar being dirty, an impression of the collar is obtained on the paper. These data are taken to the shop.

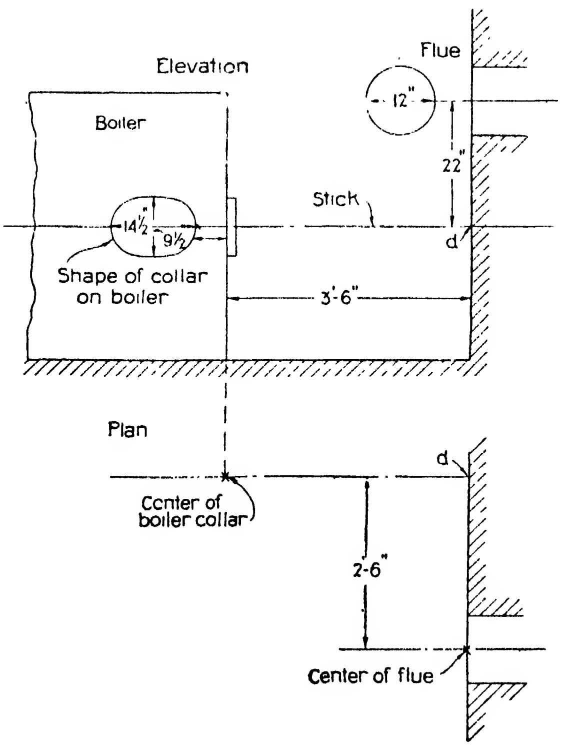


Fig. 45. Relation of Boiler and Chimney

To a convenient scale construct a side elevation of the job. That is, a vertical line will represent the boiler as indicated in Fig. 46, with a horizontal line for the center of the boiler collar. At a distance of 3 ft. 6 in. from the vertical line erect another for the chimney, and 22 in. from the horizontal draw horizontal line for the center of the flue opening; these horizontal lines continue indefinitely to the right.

It is customary for work of this nature to have fittings as near standard as possible, and if special ones are required to design them with the expectation of using

them on other jobs; for the transition, therefore, a simple oval to round shape is employed as shown in elevation by B and as a plan at C. This, to take up as little room as possible, is made with 2-in. collars and 6 in. from one profile to the other or *a* to *b* of elevation. On the lower horizontal line *s t* to place point *c*,

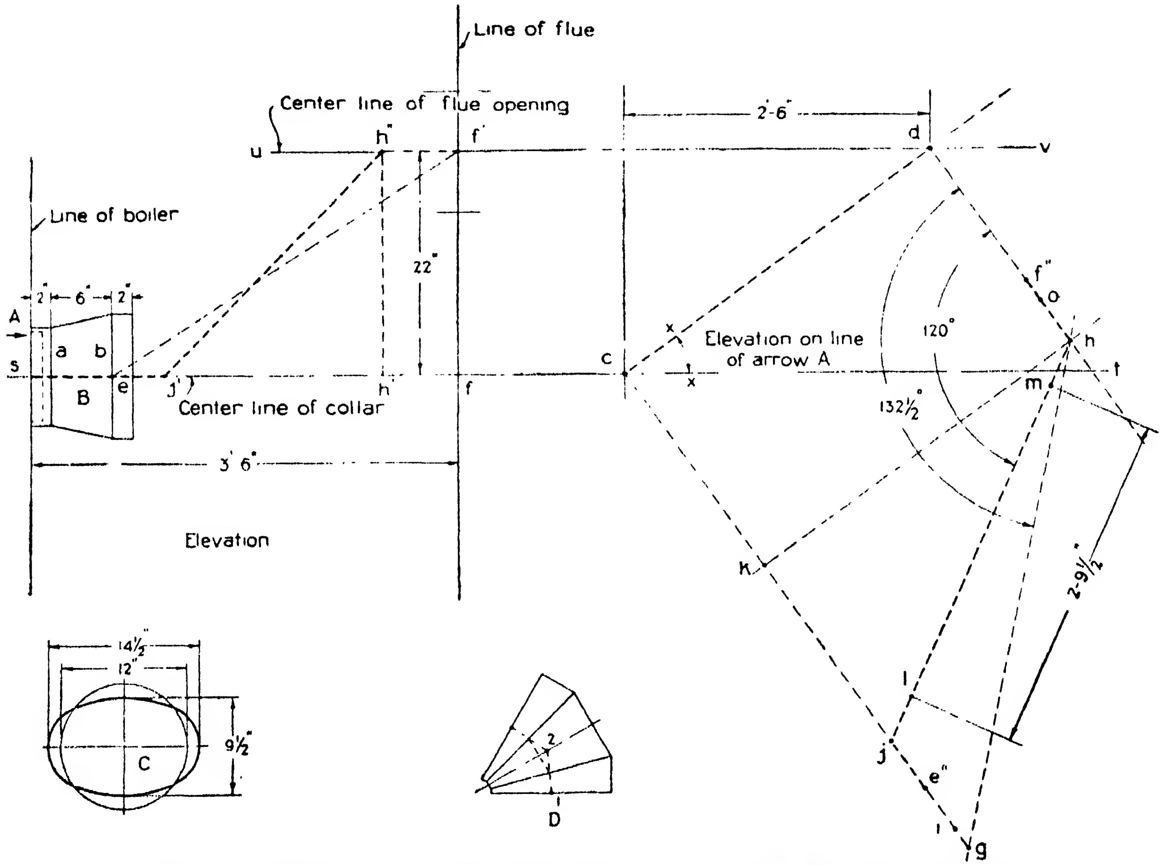


Fig. 46. Method of Determining the Length and Angles of Smoke Connection

erect a vertical line crossing the upper horizontal line *u v*, then to the right of this 2 ft. 6 in. from the line just drawn make a dot. These dots *c* and *d* are end views of the horizontal axial lines of the lines of pipe, inasmuch as a line is shown by a point when viewed on end. Connecting these points gives a line depicting the axial line of center section of the line of pipe seen on line of arrow A.

Parallel to *c d* draw a line for the base of a triangle, as K *h*. Lay off from K on *c* K to the point *g*, so that K *g* is equal to *e f* of elevation. Then *g h* is the true length of *e f'* of elevation; that is, the axial line of the middle section of the pipe connection. As standard fittings are to be used and as the throat of the elbows will require some space, the points are moved along the lines *s t* and *u v* respectively, or what is the same thing, on line *g c* and line *h d*. As this moving of the points is a changing of the angle *g h d*, point *h* may remain stationary.

Now, as the nearest standard fitting is a 45-deg. elbow, make angle *g h d* such, which establishes point *i*. Obviously this transposing of *g* to *i* does not give sufficient space for the elbows on the horizontal lines *s t* and *u v*, so a little calculation is performed, and as it is not advisable to make a turn of greater than 45 degrees with a two-piece elbow, it is decided to employ the first, last and one of the middle sections of a four-piece 90-degree elbow, D, which leaves an angle of 120 degrees and consequently establishing point *j* as indicated.

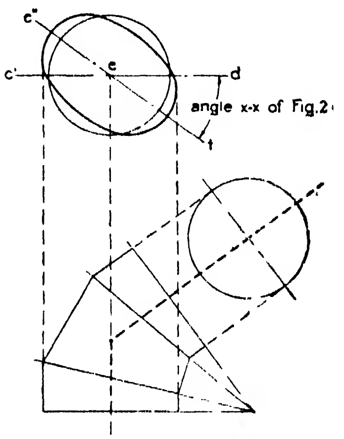


Fig. 47. Style of Fitting for Smoke Connection

So long as the distance *j k* is maintained, the locating of the points on the lines *s t* and *u v* is arbitrary; therefore point *j'* of the elevation is a distance from *e* of one half of the elbow B, allowing for the collar and an ample joint. This fixes the point *k'* (the distance *j k* of the oblique elevation) and thus the point *h''*. While this line *j' h''* is not essential, the process of obtaining it requires but a few minutes and aids the draftsman in his mental conception of the article.

The elbow D is used at both *h* and *j*. As indicated, it leaves a distance *l m* on the line *j h* that calls for a length of pipe of 2 ft. 9½ in., to which must be added an allowance for the lap of the joint. And a small piece from *o* to *b''*, with about 2 in. to go in the flue, and also allowance for lap must be provided for; say, about 1½ in.

The author of this article, together with several of his comrades in the trade, has always endeavored to lay out pipes for all classes of work just as one would erect the lines of pipes in steam or hot water heating. Simply because a line happens to have some unusual turns the steam fitter does not attempt to devise special fittings, but gets over his difficulty with what he has at hand. Should you have a dozen boilers all set differently, you could use the fitting B with suitable angle elbows to realize the offsets. Still if you really desired to accomplish the transition in the angle piece on the angle *g h d*, the process is as outlined in Fig. 46, only moving point *j'* a distance from the boiler collar to permit of an easy turn and taking the distance *j' k'* to the oblique elevation to get the true axial distances.

The profiles are placed with the center line of the round on line *c' d*, Fig. 47, and the center line of the oval on line *c' t*. Projecting to the oblique elevation one will have a fitting like that shown in Fig. 47. A round pipe elbow of the same angle is required for the flue or at *h* of Fig. 46.

PATTERN FOR A TAPERING ELBOW

For an accurate method of cutting the patterns for a two or more pieced tapering elbow, where the difference in the sizes of the ends is so small that the dividers or trammels cannot reach the long radii required by the cone method and also adaptable to elbows of heavy metal, the following exemplification applies:

The method to be employed in this case is that of triangulation. The patterns for a two-pieced tapering elbow will be developed. The same principles may be

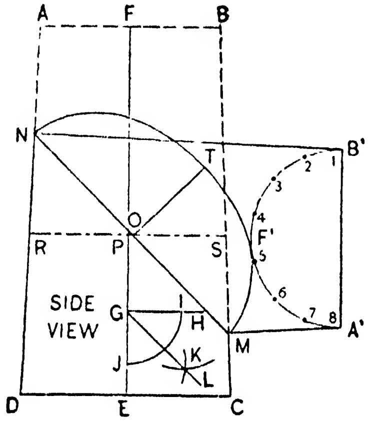


Fig. 48. Obtaining Miter Line and True Section

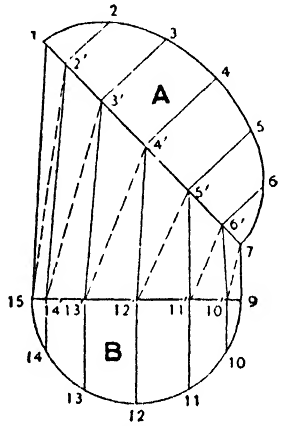


Fig. 49. Measurements for Sections

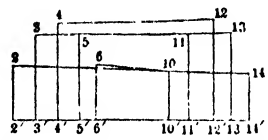


Fig. 50. Sections on Solid Lines

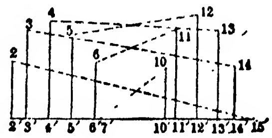


Fig. 51. Sections on Dotted Lines

applied to any angle or number of pieces. Let A B C D in Fig. 48 represent the section of a tapering pipe to be cut by the line M N so as to form a square tapering elbow when reversed and joined together, as shown by C D N B^1 A^1 M.

To obtain the line M N proceed as follows: Draw the center line F E, as shown, on which locate any point, as G. Draw G H parallel to the axis of the second piece of the elbow. Bisect the angle E G H. Next locate the desired hight C M, and from M, parallel to G L, draw the line M N. Take a tracing of N A B M and place it reversed on N M, as shown by N B^1 A^1 M. The sections on B^1 A^1 and C D are true circles, but the section on N M is an ellipse, which is obtained as follows: Through O, the center point of M N, draw the horizontal line R S. At right angles to N M, and from O, draw O T, equal in length to P R or P S. Through N, T and M, draw the semiellipse.

Take a tracing of N M C D and place it in Fig. 49, as shown by 1 7 9 15. On 1 7 place a tracing of the semiellipse, as shown by 1 4 7. On 9 15 draw the semicircle 9 12 15. Divide both the semicircle and semiellipse into the same number of equal spaces, as shown by the small figures. At right angles to 1 7 and from points 2, 3, 4, 5 and 6 draw lines intersecting 1 7 at 2′, 3′, 4′, 5′ and 6′. In

similar manner, at right angles to 9 15 and from points 10, 11, 12, 13 and 14, draw lines intersecting 9 15 at 10′, 11′, 12′, 13′ and 14′. Draw solid lines from 2′ to 14′, 3′ to 13′, 4′ to 12′, 5′ to 11′ and 6′ to 10′; and dotted lines from 2′ to 15′, 3′ to 14′, 4′ to 13′, 5′ to 12′, 6′ to 11′ and 7′ to 10′. The exact, or true length, of these lines will be determined by constructing a series of sections, the bases of which are the aforesaid lines and the outer sides or ends to be coincident in size to like numbered lines of the semiprofiles, A and B. The connecting lines to these or rather, the remaining side of the sections will be the required lines of true length. The mentioned sections are constructed as follows:

In Fig. 50 draw any horizontal line, as 2′ 14′, upon which place the lengths of all the solid lines shown in Fig. 49. From these points, on and at right angles to 2′ 14′ in Fig. 50, erect lines equal to the altitudes in the semiprofiles in Fig. 49 having similar numbers. Draw lines connecting the ends of the proper vertical lines. These will represent the actual distances on the finished article, of similarly numbered lines in Fig. 49. In precisely the same manner obtain the sections on dotted lines in Fig. 49, as shown in Fig. 51.

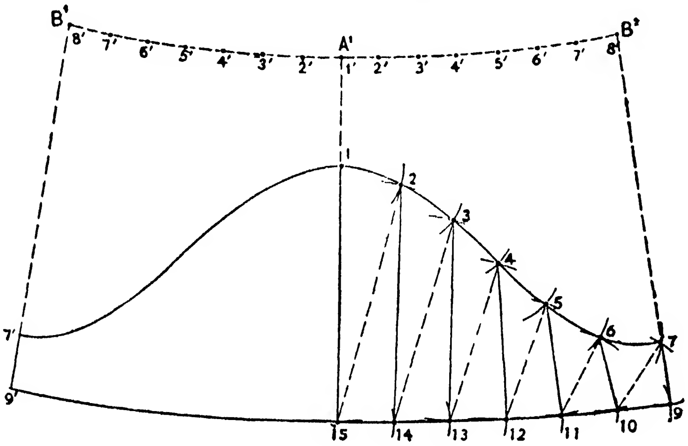


Fig. 52. The Patterns

For the pattern, draw any vertical line, as 1 15, in Fig. 52, equal in length to 1 15 in Fig. 49. With 1 2 in A as radius and 1 in Fig. 52 as center describe the arc 2, which intersect with an arc struck from 15 as center and 15 2 in Fig. 51 as radius. Then with 15 14 in B in Fig. 49 as radius and 15 in Fig. 52 as center describe arc 14, which intersect by an arc struck from 2 as center and 2 14 in Fig. 50 as radius. Proceed in this manner until 7 9 in Fig. 52 has been obtained, which is measured from 7 9 in Fig. 49. Trace a line through the intersections obtained in Fig. 52; then will 1 7 9 15 be the half pattern for the lower arm of the elbow.

As the elbow has an equal taper throughout, the pattern for the upper arm A^1 B^1 N M may be obtained by extending 15 1 in Fig. 52 indefinitely, as shown, and making 1 A^1 equal to M A^1 in Fig. 48. Through A^1 in Fig. 52 draw the curve A^1 B^2 parallel to 15 9. On A^1 B^2 lay out the stretchout of the half section on A^1 B^1 in Fig. 48. In Fig. 52 continue 9 7 to 8′. Then will 1′ 8′ 7 1 be the half pattern of the upper arm. Trace this to the left of A^1 15 for full pattern.

METHOD OF SUPPORTING SHEET METAL FLUES

In the ventilation of large buildings where sheet metal flues are carried up from the basement to furnish means for the distribution of air to rooms desired, there are numerous little kinks which greatly facilitate the work, but are usually developed by experience. Of course, the majority of the forming is done either at the shop or in temporary quarters located on the job, if it is a big one, but it is inconvenient to handle ducts which are usually 20×28 in. in size or thereabouts, in lengths of over 14 ft. Consequently arrangements must be made so that pipes can be readily entered one to another.

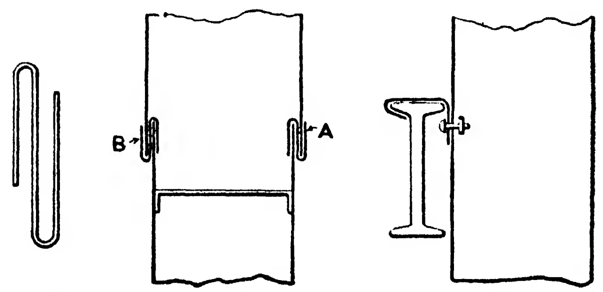


Fig. 53. Fig. 54. Fig. 55.
Erecting and Supporting Ventilating Ducts

In Fig. 53, a section is shown of a device which is used to facilitate this work. These bent pieces of sheet iron are slipped over each piece of pipe in such a manner that the inside loop hangs over the lower piece of pipe, while the outside piece of pipe is ready to receive the upper piece of pipe. This is shown more clearly in Fig. 54, which gives a rather exaggerated section of the top of the pipe indicating the taper, but it serves as an outline to illustrate the method of fastening, making obvious the ease with which work can be erected by this method. At the points marked A and B in Fig. 54, a hole is drilled through all the sheet metal work with a fiddler's drill and a common wood screw inserted, after which the ventilating ducts can be handled and lifted with little or no danger of their coming apart. Of course, after the ducts are finally in place they are riveted together, but this forms a temporary holding power. There are numerous other forms of "slips"; but these are the fundamental principals of all and the most popular.

In some cases long vertical ducts are supported from the bottom, but this is not desirable in many cases, as it throws the entire load at one point, consequently the method shown in Fig. 55 is frequently employed. A band of iron usually 1/8 or 3-16 in. in thickness by 1¼ in. broad is hooked over a steel I beam or some other substantial part of the building framework, and turned in such a manner that a bolt may be passed through this and the sheet metal work, giving it support on either side. These supports are usually made at every floor of a building, but staggered on either side of the ventilating duct so that support is afforded both sides of the pipe.

HEAVY METAL PATTERNS FOR PIECED ELBOWS

This treats of a method of obtaining the patterns for an elbow, made of any number of pieces out of heavy material, so as to get the large and small diameters of each piece, the miter joints to be riveted as shown in Fig. 56, in which the large end in all of the pieces is indicated by L E and the small end which goes into the large end is shown by S E. Or, as better shown by Fig. 57, which being a section, shows how pieces are lapped for riveting. It makes no difference how many pieces the elbow may have, the principles will be similar to those given in the four-pieced elbow in Fig. 58.

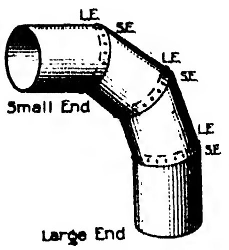


Fig. 56. Perspective

First draw the side elevation of the elbow desired, in this case four-pieced, as shown by *s t u v*, and from the corners E, F and G draw miter lines to D. Add the straight pieces of pipe as shown by A D and B C, making them equal to the outside diameter of the normal profile of the pipe. In other words, if the inside diameter of the normal or given profile of the pipe is 20 in. and the elbow is to be made of metal 3-16 in. thick, then the distances B C and A D will be made 20⅜ in. Knowing the outside diameter of the normal pipe, complete the side elevation of the elbow. Number the pieces I, II, III and IV. Directly below the line B C draw the normal profile of the pipe, struck from the center *m*. The thickness of the metal is shown by X. Assuming that the pieces are to fit into one another as shown in Fig. 57, or by the direction of the arrow H in Fig. 58, then the large ends would be at the lower ends of the pieces I, II, III and IV and the small ends at the upper ends of similar pieces I, II, III and IV.

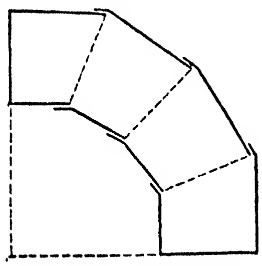


Fig. 57. Method of Joining

Divide the outer curve, representing the outer diameter of the pipe, into equal parts, as shown from 1 to 5, in the semicircle in the normal profile, and take twice the girth from 1 to 5 and place it on the horizontal line K as shown from 1 to 5 to 1^v. From 1^v set off the distance 1^v *a* equal to 7 times the thickness of the metal in use. Using 1 as a center and 1 *a* as radius, describe the arc *a* 1°, which intersect by a perpendicular line erected from 1^v at 1°. Draw a line from 1° to 1, and from the various divisions 2 to 5 to 2 on the line J K erect perpendiculars until they intersect the slant line 1° 1, at 2° to 5° to 2°. This length 1° 1 is then the true girth for the wide end of the pipe; in other words, when this girth 1° 1 is rolled up, the normal profile shown below the elevation will fit inside of same.

To obtain the girth of the small end of the pipe, which will give the true inside diameter as called for in the normal profile, take 3½ times the thickness of

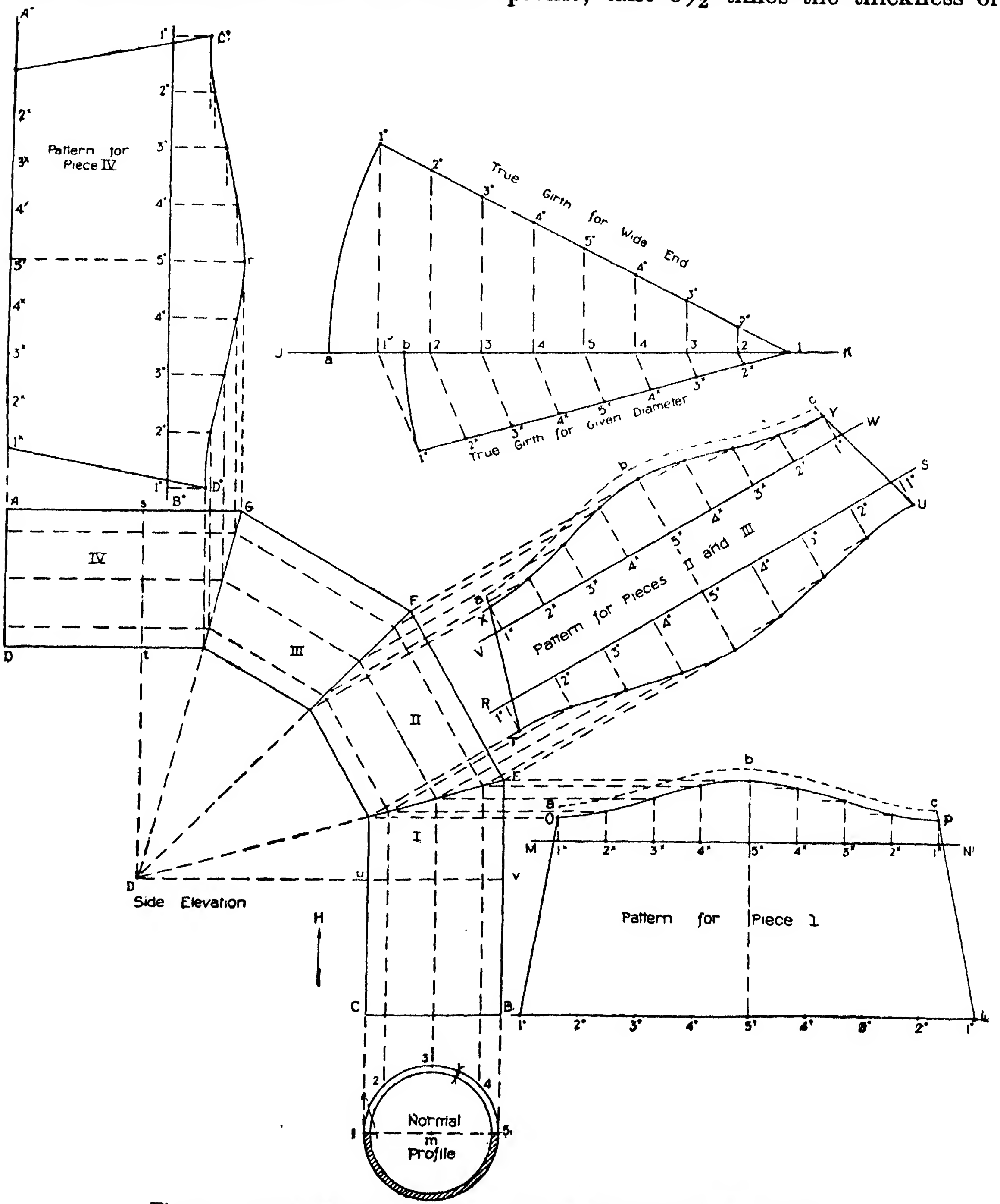


Fig. 58. Details of Pattern for Pieced Elbow Made From Heavy Metal

the metal and deduct it from the length 1ᵛ 1 on J K as shown from 1ᵛ to *b*. Then using 1 as center and 1 *b* as radius, draw an arc of any desired length, as *b*

1^x, and draw a line from 1^x to 1. Draw a line from 1^v to 1^x and parallel to this line from the divisions 2 to 5 to 2, draw lines until they intersect the line 1^x 1, from 2^x to 5^x to 2^x. Then will the length 1^x 1 represent the true girth for the small or given diameter of the pipe, which, when rolled up, will correspond to the normal profile. In practice it is only necessary to find the one division 1°, 2° on the wide end and the one division 1^x, 2^x on the small end, as the other respective divisions are equal.

The true girths having been obtained, the patterns are now in order. The taper in the patterns is greatly exaggerated to make the various operations clear and distinct. To obtain the pattern for piece I, take the girth of the wide end from 1° to 5° to 1 and place it on the line C B extended as B L, as shown by similar numbers 1° to 5° to 1°. At right angles to E B, at any point between E and B draw the line M N, which intersect at 5^x by a line erected from the center point 5° at right angles to B L. Take the half girth 5^x to 1^x of the small or given diameter, and place it on the line M N, on either side of the center line 5° 5^x, as shown by the divisions from 5^x to 1^x. At right angles to M N, through the small figures on same, erect vertical lines, which intersect by lines drawn parallel to M N, from similar numbered intersections on the miter line E D. Trace a line through points thus obtained as shown by O P, and draw lines from O to B and from P L. Then O P L B will be the pattern for piece number I.

To obtain the pattern for pieces II and III, draw any two lines at right angles to E F, as shown by V W and R S. On the lower line R S place the girth of the wide end as shown from 1° to 5° to 1°, and through 5° at right angles to R S erect a line intersecting V W at 5^x. On either side of 5^x place the semigirth 5^x 1^x equal to the semigirth 5^x 1^x of the given diameter or small end of the pipe. At right angles to R S from the various divisions 1° to 1°, draw lines which intersect by lines drawn parallel to R S from similar numbered intersections on the miter line E D. Trace a line through points thus obtained as shown from T to U. In a similar manner at right angles to V W, from the intersections 1^x to 1^x erect lines, which intersect by lines drawn parallel to V W from similar intersections on the miter line F D. Trace a line through these intersections as shown from X to Y and draw a line from X to T and from U to Y. X Y U T will be the pattern for pieces II and III.

In this connection it may be proper to remark that if the elbow were made of 10 pieces which would have 8 middle pieces, then the pattern obtained for the first middle piece, as II in this case, would answer for all 8 in the 10-pieced elbow, in the same manner as the pattern for II in this case also answers for III, because the miter joints lap the same as shown in Fig. 56.

For the pattern for piece IV in Fig. 58, extend the line D A as A A°, on which place the girth of the small end of the pipe, as shown from 1^x to 5^x to 1^x. From the center 1^x at right angles to A A° draw the line 5^x r, which intersect at 5° by the line B° J drawn at right angles to A G at any desired point, between A and G. Take the semigirth of the wide end from 5° to 1° and place it on either side of 5° on the line B° J, as shown from 5° to 1°. Through these small figures at right angles to J B° draw lines, which intersect by lines drawn parallel to J B° from similar numbered intersections on the miter line G D. Trace a line through points thus obtained as shown from C° to r to D°, and draw lines from D° to 1^x and from C° to 1^x. Then will 1^x C° r D° 1^x be the pattern for piece IV.

A lap must be allowed along the seam for riveting, also a lap for riveting along the miter joint as indicated by *a b c* in the patterns. The laps along the miter joints must be flanged to the proper angle.

PATTERN FOR A Y OBLONG TO ROUND

To describe the pattern for the Y shown in Fig. 59, the first step is to construct a section on H E. As the width through the point H is equal to I K in plan, or A B in elevation, and the hight to H E, draw at pleasure the shaded section A E B.

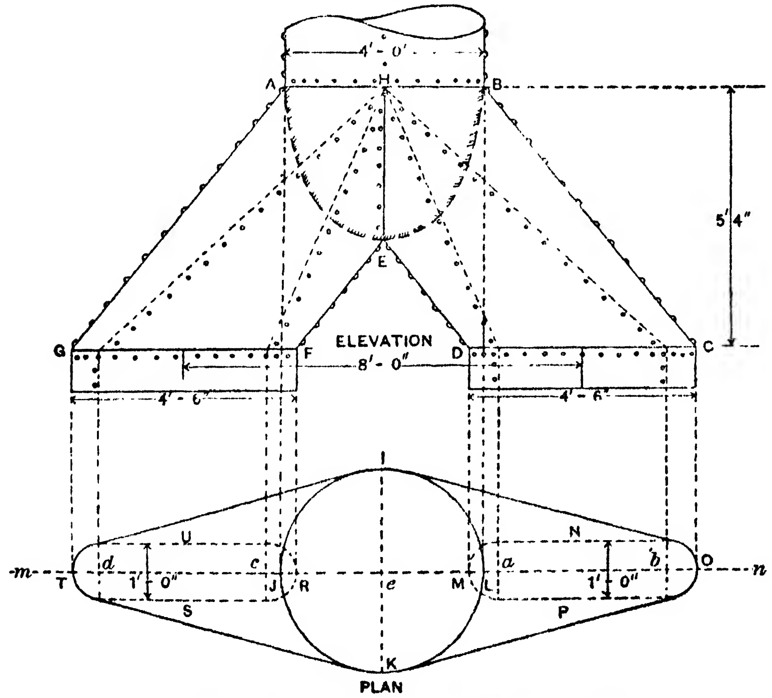


Fig. 59. Plan, Elevation and Section on H E

Take a tracing of H B C D E, and place it as shown by 10′ 1 2 7 8 in Fig. 60; a tracing of A H E in Fig. 59, and place it as shown by 10 10′ 8 in Fig. 60, and a tracing of the quarter section I *e* L in plan in Fig. 59, and the half section M P O, and place them in Fig. 60, as shown by 10″ 10′ 1 and 7 5 4 2 respectively. Divide the quarter circles in *a* each into two equal parts, as shown by 2, 3, 4, 5, 6 and 7. Also divide the two sections *c* and *b* into two equal parts, as shown

by 8, 9 and 10, and 10″, 11, 1. In practice more space should be employed. At right angles to 2 7, 8 10′ and 10′ 1, and from the various points just obtained in the profiles *a*, *c* and *b*, draw lines to their respective base lines. Connect opposite points, 1 to 3′ to 11′ to 4′ to 10′ to 5′ to 9′ to 6′ to 8. Then will these lines represent the bases of sections which will be constructed, the altitudes, or hights, of which are

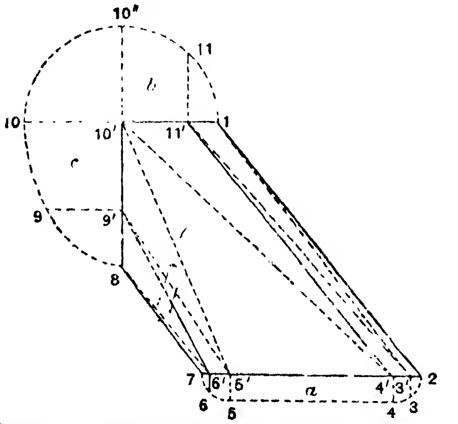


Fig. 60. Obtaining Measurements for Sections

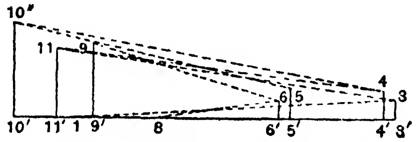


Fig. 61. Diagram of Sections

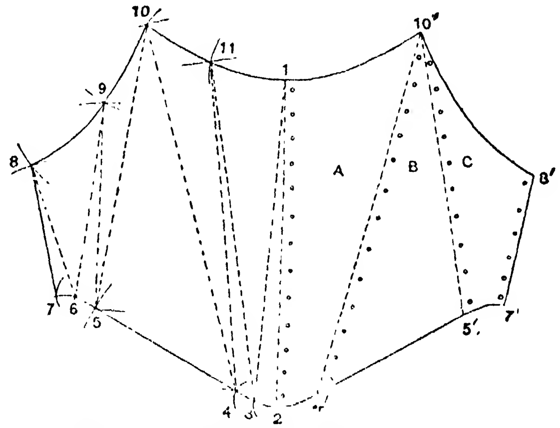


Fig. 62. The Pattern Shape

equal to similar numbers in the sections *a*, *b* and *c*, as indicated in Fig. 60.

In Fig. 61 is shown the method and diagram for obtaining the true lengths of the dotted lines in 1 2 7 8 10′ in Fig. 60.

For the pattern draw 1 2 in Fig. 62, equal to 1 2 in Fig. 59. Now using 2 as center and 2 3 in *a* in Fig. 60 as radius, describe the arc 3 in Fig. 62, which intersect by an arc struck from 1 as center and 1 3 in Fig. 61 as radius. Then with 1 11 in *b* in Fig. 60 as radius and 1 in Fig. 62 as center describe the arc 11, which intersect by an arc struck from 3 as center and with 3 11 in Fig. 61 as radius. Proceed in this usual manner until the line 7 8 in Fig. 62 is obtained. Trace a line through points thus found. Then will 1 10 8 7 2 be the half pattern.

If the Y were smaller and a pattern is desired in one piece, trace the half pattern opposite. As the Y in this case is of such large dimensions and is to be made from No. 10 steel, each branch had better be made in six parts, three of which are shown punched for riveting at A, B and C in Fig. 62. If a lap joint is required the laps must be added to the dividing lines in the pattern, or if butt joints are wanted it will be necessary to punch on either side of the lines in pattern. The elevation in Fig. 59 shows the joints riveted, using a lap joint. Laps must be allowed to the top and bottom of the pattern to allow the stack and neck collars to be riveted to same, as shown in Fig. 59.

ADJUSTABLE SLEEVES FOR STEAM PIPES

In buildings that are constructed in conformity with the requirements of the fire underwriters and the fire protection regulations of large cities, it is necessary to protect the material of the various floors through which the large steam mains and returns pass in going to the various radiators supplied. Steam fitters who engage in such work, whether the floors are composed of terra cotta and concrete supported by iron beams or wooden joists and floor covering, are accustomed to inclose the steam pipes in a sheet metal casing. These sleeves are so arranged that they are adjustable to different thicknesses of floors and allow free expansion and contraction of the steam pipes.

The method of construction is shown in the accompanying illustration, Fig. 63, although the methods of different shops vary. The sections consist of two parts, the upper section being shown at the left and the bottom section at the right, while the two sections connected are shown in the center. The sections consist of a sheet iron cylinder or rectangular tube, either double seamed or riveted together, of suitable dimensions to inclose the pipes in connection with which they are used. In some shops, after cutting the two holes in the top piece and the bottom piece for the pipes to pass through, little angle formed lugs are riveted to the sleeve proper, and these, in turn, are riveted to the top and bottom piece, forming practically two boxes open at one end. In addition to the holes for the pipes two small holes are provided for the connecting rods, which are threaded at both ends for nuts. The two sections are made of slightly different size, so that one can readily slip into the other. When the steam fitter is running his risers he puts on a top piece and a bottom piece at each floor. The top piece naturally rests on the floor by gravity, while the bottom piece must be held by one workman while another workman assists in making the connection between the two parts and screwing up the rods which hold them securely in place. Steam fitters doing a large business, in the majority of cases have a sheet metal working shop for the making of ducts, fan systems and the like, work that is coincident to a steam fitting business; manufacture their own sleeves, although there are sleeves in the market that can be purchased for this purpose.

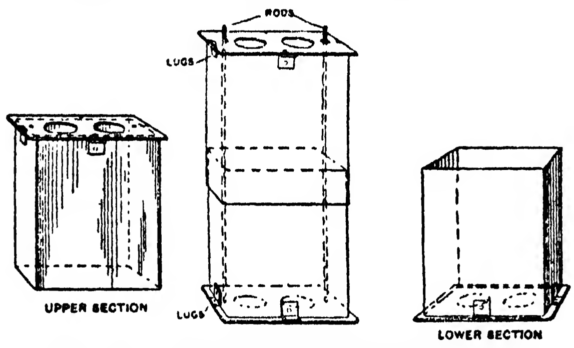


Fig. 63. Adjustable Sleeves for Steam Pipes

PATTERNS FOR ELBOWS MITERING WITH ROUND PIPE

In this article it will be shown how to obtain the patterns for the Y shown in Fig. 64, which is formed by means of an elbow springing from a vertical pipe, and also for the T shown in Fig. 65, formed by means of two elbows joining together as shown. In the former case the vertical pipe is 18 in. in diameter, and the diameter of the elbow 12 in. In the latter case both elbows and pipe are 18 in. in diameter. The problem shown in Fig. 64 will be worked out in detail, showing how the principles can also be applied to Fig. 65. It is immaterial what diameter the pipe or elbow may have, or how many pieces are contained in the elbow, or what radius is used in striking the throat of the elbow, the principles hereinafter given are applicable to any case.

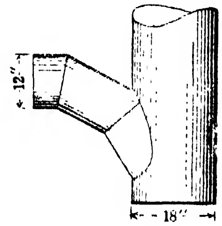


Fig. 64. Single Elbow

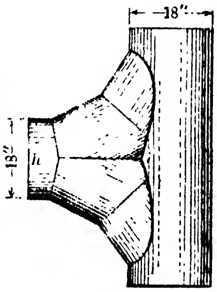


Fig. 65. Double Elbow

In Fig. 66 draw any horizontal line as A B and with any point on this line as A, describe the elbow shown by C D E F G H J K L M. In its proper posi-

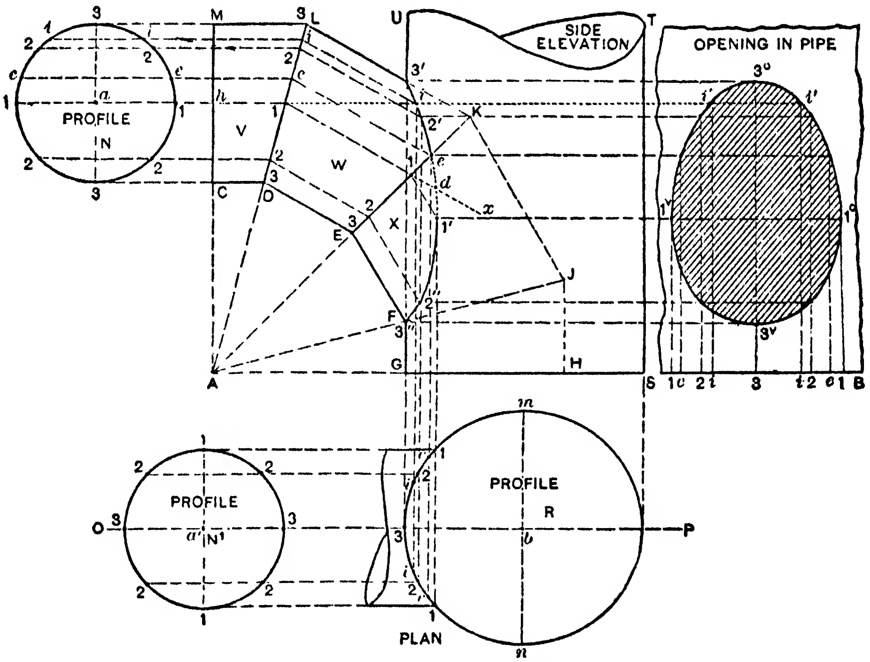


Fig. 66. Plan, Elevation, Profiles and Pattern

tion draw the profile through M C of the elbow as shown by N, struck from the center a; and in its proper position below the elevation G S T U of the pipe draw the profile through G S of the pipe, as shown by R, struck from the center

b. Through the center *a* in the profile N draw the two diameters as shown, and divide the circle into equal spaces, in this case but eight, as shown, from 1 to 3 to 1, etc.

Through the center *b* in the profile R draw the line O P, upon which locate at pleasure the center point a^1, which use as center to describe the profile N^1, similar in size and divisions to the profile N. Notice that if points 1 and 1 are at the sides in profile N in elevation, they will be at top and bottom in profile N^1 in the plan, which represents the sides when viewed from the top. Now through the various intersections 1 to 3 in the profile N^1 in plan draw lines parallel to O P until they cut the profile of the main pipe R, as shown from 1 to 3 to 1. In similar manner, through the various points of intersections 1 to 3 in the profile N in elevation, draw lines parallel to M L, until they cut the miter line L D of the elbow, as shown from 3 to 1; from these intersections on L D, parallel to L K, draw lines until they cut the miter line K E, from which points, parallel to K J, draw lines indefinitely, as shown, and intersect these lines by lines drawn parallel to G U of the pipe, from similar intersections in the profile R, thus obtaining the points of intersections 3′, 2′, 1′, 2″ and 3″. Trace a line from 3′ to 2′ and from 1′ to 3″.

Before a line can be traced from 2′ to 1′ it is necessary to know where the miter line between the elbow and main pipe will cross the miter line K E of the pieced elbow, and is obtained as follows: Assume that the cylindrical portion W of the pipe intersects the main pipe. Therefore extend the required line following 2′, which is 1 as from 1 to *x* and intersect it by a vertical line erected from 1 in the profile R locating point *d*. Extend the miter line 3′ 2′ to *d*, as shown, and where this curved line crosses the miter line K E is the desired point, or *e*. From *e* complete the miter line *e*, 1′, 2″, 3″, and it will be found that this line will pass over the one previously drawn to *d*, owing to the small size of the drawing, which however, will not be the case when drawn full size. From the intersection *e* drop a vertical line, until it meets the profile R at *e* and *e*. In similar manner from the intersection *e* on the miter line K E draw a line parallel to K L until it meets the miter line L D at *e*, from which point, parallel to L M, draw a line intersecting the profile N at *e* and *e*. Then will the miter line from 3′ to *e* to 3″ in elevation represent the intersection between the elbow and main pipe. All that part of the elbow shown by dotted lines K J and H will not be required.

The development of the patterns is now in order. To obtain the opening to be cut in the main pipe take the girth of the various spaces contained in the profile R of the main pipe, as shown from the horizontal line S B. From these points at right angles to S B erect vertical lines, which intersect by horizontal lines drawn from

similar numbered and lettered points in the miter line $3'$ e $3''$ in elevation. A line through 3° 1^v 3^v 1°, gives the opening in the main pipe, shown shaded.

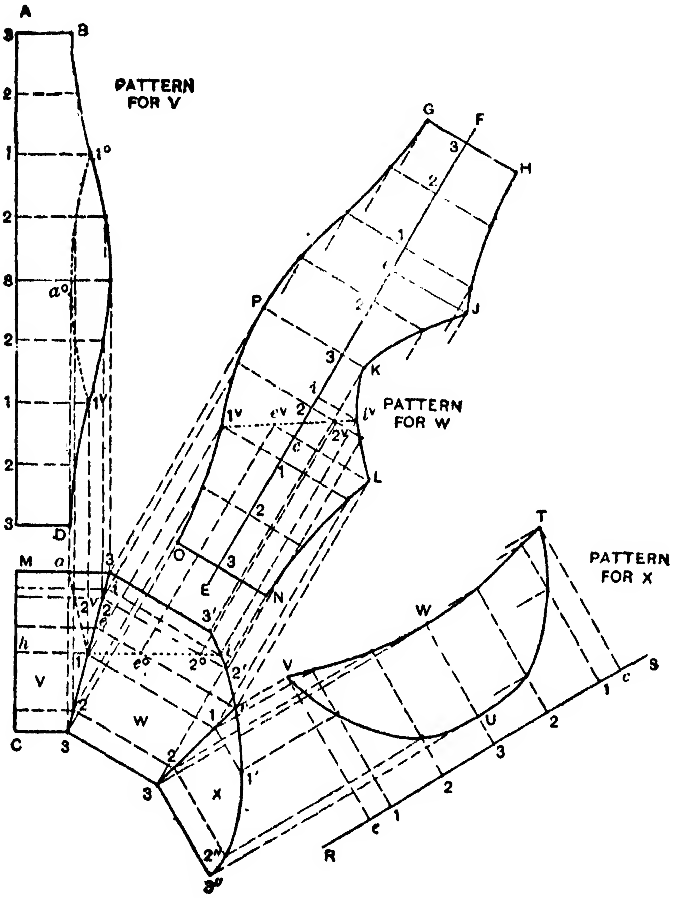


Fig. 67. Developing Pieces in the Elbow

To obtain the patterns for the pieces V, W and X, a tracing of these pieces, with the various points of intersections, has been transferred to Fig. 67, as shown by similar letters and figures. Now, to obtain the pattern for V, extend the line C M, as shown by M A, upon which place the girth of the profile N. From these points at right angles to M A draw lines, as shown, which intersect by lines drawn parallel to M A from similar numbered intersections on the miter line between the pieces V and W, then will A B D 3 be the pattern for piece V.

The pattern for piece W is obtained by drawing the girth line E F at right angles to 3, 3 in W, and placing on this the girth of the profile N in Fig. 66, being careful to include the intersections e between 1 and 2, as shown by similar letters and figures on E F in Fig. 67. Through these points at right angles to E F draw lines indefinitely, which intersect by lines drawn parallel to E F from similar lettered and numbered points of intersections on the miter line 3, 3 on the left of W and the miter line $3'$ e 3 on the right. When a line is traced through points thus obtained, as shown by G P O on the left, and N L K J H on the right, the desired pattern with seam in throat will be obtained.

For the pattern for X, draw the line R S at right angles to 3 $3''$, upon which place only the girth of the lower part of the profile N in Fig. 66, from e to 3 to e (as only that much of the profile miters with the main pipe in elevation from e to $3''$). Proceed as before, T U V W T being the pattern desired.

If desired these patterns can be proved thus: Measure the various intersections in opening in pipe in Fig. 66 from 3^v to 1° or 3^v to 1^v, and compare them with the

various spaces in pattern for X in Fig. 67 from U to T or U to V respectively. In similar manner the various spaces in pattern for opening in Fig. 66 from 1° to 3° to 1^{v} are compared to similar intersections in pattern for W in Fig. 67 from J to K to L respectively. This, then, completes the patterns for a single elbow mitering on a pipe similar to that shown in Fig. 64; laps or edges of course, to be allowed for riveting or seaming.

The second case shown in Fig. 65, shows a double elbow mitering on a pipe, in which both diameters of the pipe and elbow are equal. To show this problem would require another set of drawings, and to avoid this, as the principles are similar, assume that the double elbow is to be 12 in. in diameter, thus allowing the drawings and patterns already described to be used in developing the patterns for an elbow similar to Fig. 65, excepting the change in diameters. While the elbow in Fig. 66 intersects the main pipe in plan as far as 1 1, if this elbow were of the same diameter as the main pipe, it would intersect the main pipe at *m* and *n*, the principles in all the operations, however, being similar, as before explained.

All that would be necessary, if a double elbow were to intersect the main pipe in Fig. 66, is to draw a horizontal or miter line from the center *a* in the profile N until it cuts through the elevation of the elbow, as shown by *h i*. This line *h i* then represents the joint line between the two elbows, as indicated by *h i* in Fig. 65. In its proper position draw the line *h i* in Fig. 67, crossing the lines *e* and 2 in piece W at e° and 2°. Now take a tracing of *h i* 3″ C in Fig. 66 and double it on the line *h i*, as shown by similar letters and figures in Fig. 68, thus showing the appearance of the double elbows from dimensions obtained from Fig. 66. Thus it will be seen that the pattern for X in Fig. 67 remains the same for X^1 in Fig. 68, but a change of pattern will be required for W^1, because they miter along *h i*, and is obtained as follows:

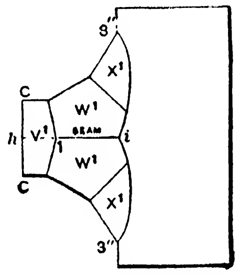


Fig. 68. Elbow Doubled From Fig. 66

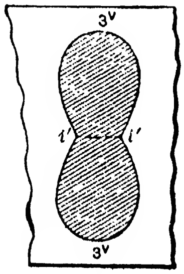


Fig. 69. Opening for Double Elbow

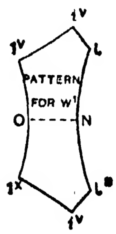


Fig. 70. Pattern for W1, Fig. 68

From the intersection *i* in elevation in Fig. 66 drop a vertical line in the plan cutting the profile R at *i* and *i*. Take the distance from 2 to *i* on both sides in profile R and place it on the girth line S B, also shown from 2 to *i* on both sides, and from the points *i* erect vertical lines, which intersect by a horizontal line drawn from point *i* in elevation, thus obtaining points i^1 i^1 in the pattern. Take a tracing of i^1 3^v i^1 and place it as shown in Fig. 69, by i^1 3^v i^1, tracing it on either side or

the line i^1 i^1. This represents the pattern for the opening to be cut in the main pipe, to receive the double elbow shown in Fig. 68.

Again referring to Fig. 66, from the intersection *i* in elevation draw a line parallel to the piece W until it intersects the miter line L D at *i*. From this point draw a horizontal line, cutting the profile N also at *i* and *i*. Take the distance from 2 to *i* in profile N on either side and place it on one side of the girth line E F in Fig. 67, as shown, from 2 to *i* between 2 and 3. From *i* draw a line perpendicular to E F, as shown, which intersect by a line drawn parallel to E F from the intersection *i* on the miter line 3′ *e*. In similar manner from the intersections 2° and e° draw lines parallel to E F, intersecting the lines 2 and *e* in the pattern at 2^v and e^v, respectively. Draw the miter cut as shown dotted from 1^v to i^v. Then will 1^v O N L i^v be the half pattern; for the full pattern trace this half opposite the line O N, as in Fig. 70, which represents the pattern for the pieces marked W^1 in Fig. 68 with a seam along 1 *i*.

To obtain the full pattern for V^1, simply draw a line from 1 to *a* in V in Fig. 67, crossing line 2 at 2^v, and project points into the pattern for V, as shown. Then will A B 1° a° 1^v D 3 be the pattern for V^1 in Fig. 68. Laps and edges must be allowed on these patterns for seaming purposes.

OBVIATING NOISES IN FAN SYSTEMS

A complaint often heard in reference to a heating or ventilating system which depends upon a blower or suction fan to keep the air in motion is that the sound of the vibration of the fan is transmitted so plainly by the metal ducts and flues that it becomes an annoyance. A good way to avoid this is to put in a canvas joint where the fan collar connects to the duct. To make the connection the metal duct should not start at the collar of the fan, but a gap of several inches should be left, which gap should be filled in by means of the canvas joint.

In making the connection to the fan consider that the collar is rectangular or square and take a strip of galvanized iron long enough to go around the collar and wide enough to fold up into the canvas. The first step will be to form the metal as shown by Fig. 71. Slip the canvas into the fold of the metal as far as it will go and clinch it down in the folder or brake, or close it down with a mallet. The next operation is shown in Fig. 72, which is merely turning the galvanized iron over in the brake and mashing it down. When holes are punched through this to correspond with the holes in the collar of the fan, this end of the expansion joint

is ready to be attached to the collar of the fan, which is done by bolting it as shown in Figs. 75 and 76. By this method the canvas is folded into the galvanized iron in such a way that it cannot get out. Both edges of the galvanized iron should be hemmed before the strip is bent, so there will be no sharp edges to cut the canvas.

The end of the canvas joint that joins the duct should have a piece of galvanized iron folded over it somewhat similar to the end next to the fan, and this should be turned up and clinched up over an edge turned out square on the top, bottom and both sides of the duct. The first step in preparing this end of the joint is to hem one edge of the galvanized iron and fold it over the canvas, as shown in Fig. 73, and close the edge down tight. Fold this over and close it down tight, as shown in Fig. 74. Next turn 1 in. up square and 1 in. out square, as shown by dotted lines in Fig. 74. Then turn 1 in. out square all around on the metal duct, bolt the canvas joint to the collar of the fan, sew the canvas where it laps on the longitudinal joint, slip the edge shown by the dotted lines in Fig. 74 over the edge turned out on the duct; turn it down, hammer it tight and put a few rivets or bolts through to make sure the joint will not come apart. This makes a practically airtight joint and one which will allow the air to flow freely, but which will transmit none of the vibration to the ducts. The joint in section would appear as in Fig. 75.

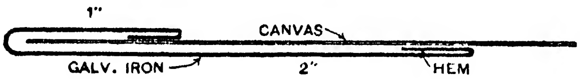


Fig. 71

Fig. 72

Fig. 73

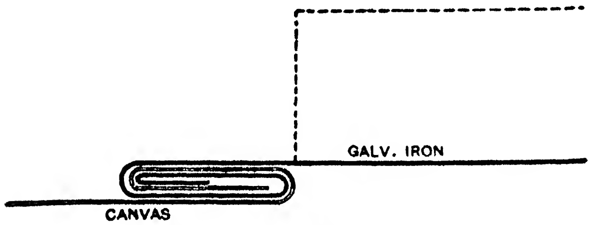


Fig. 74
Method of Joining the Canvas and Metal

If the collar of the fan happens to be round, the galvanized iron can be folded on the canvas at the side which will fit on the collar of the fan, and the galvanized iron folded on the side of the canvas that fits onto the circular duct the same as shown in Fig. 74, before the edges shown by the dotted lines are turned. This would leave that edge of the galvanized iron flat, as shown by the solid lines in Fig. 74. The canvas strip, with the metal binders clinched to each side, would then be formed up in the rollers to fit the collar of the fan and the end of the metal duct, and would be bolted to the collar of the fan the same as in Fig. 75, but the side next to the duct would lap over same and be soldered and riveted instead of having an

edge turned up and over as it would in the case of the square or rectangular duct. The joints for the circular duct would then be as shown by Fig. 76.

The longitudinal joint in the canvas would be sewed. Care should be taken with these joints, especially for round collars, to allow for the thickness of the material, as this will be considerable, as there are four thicknesses of galvanized iron and two of canvas, which will aggregate from ⅛ to ¼ in. in thickness, which means from ¼ to ½ in. added to the diameter of the fan collar, or ⅞ to 1¾ in. to the circumference.

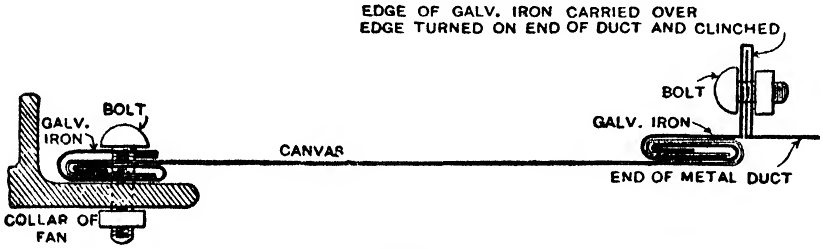


Fig. 75

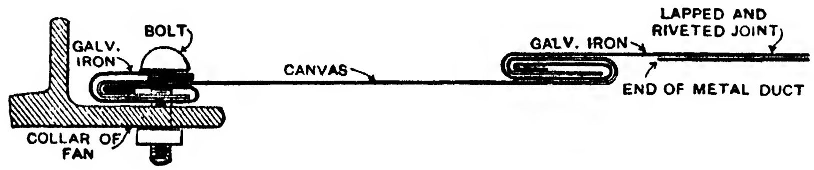


Fig. 76
Sections Showing Canvas Connections

Fig. 77 shows another construction of a flexible joint for a circular pipe. The ends are located 4 to 6 in. apart and connected by the canvas sleeve which is slipped over the bead on the pipe, doubled under at the ends and secured in place by annealed galvanized wire drawn up tight.

For rectangular pipes the method shown in Figs. 78 and 79 may be used. The canvas is doubled under as before and held in place by stove bolts passing through

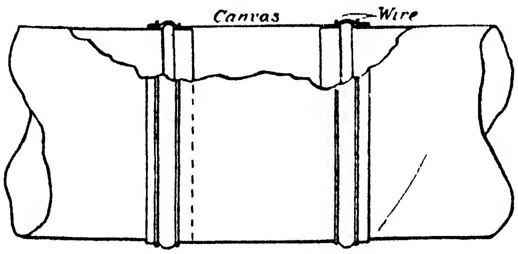
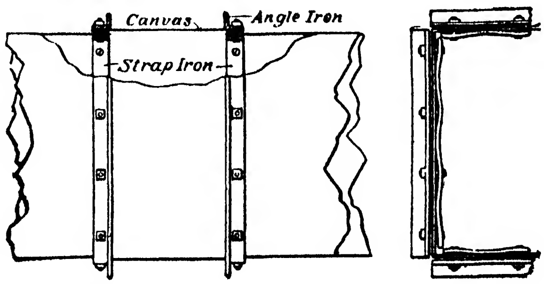


Fig. 77. Flexible Joint for Round Pipe



Figs. 78 and 79. Joint for Rectangular Pipe

the angle iron, canvas, galvanized iron and the strap iron inside the duct. The holes should be punched about 4 in. on centers, and before putting the strap iron in place in the inside of the duct, it should be placed on supports, the same distance on centers as the holes, and slightly bent as in Fig. 79, so that when drawn up in place by the bolts, the spring in the iron will force the galvanized iron hard against the canvas between it and the angle iron, making a tight joint. Canvas joints of

this description should be thoroughly painted after they are put in place, to prevent the leakage of air.

CONSTRUCTING A RECTANGULAR DUCT

In Fig. 80 is presented a sketch, which shows a plan view of a duct, A, 30× 80 inches in size at its largest section and 31 feet long, having five branches or outlets of the size as indicated. A section taken through B C would appear as shown by D, which makes the depth of the duct 30 inches and the side view of the branch 20 inches, as shown in plan. Then, in this case, the connections between the branches and duct should take place on the lines X, X, X, etc., the side of the branch appearing as shown by J E F H in section D, connecting the 20-inch opening of the branch to the 30-inch opening of the duct by means of the curved corners, as shown.

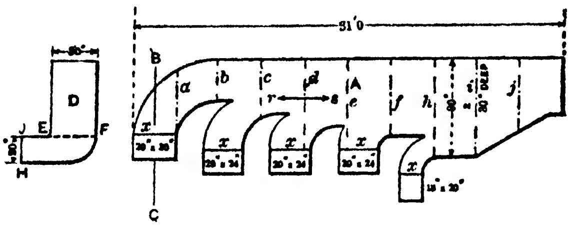


Fig. 80. Plan of the Duct to be Made

In constructing a large duct of this kind, where a number of sheets are to be joined together, a rigid construction must be provided for. While there are various methods employed, the one shown in Figs. 81 and 82 is usually adopted, as it prevents sagging in the middle. Assuming that iron 36 inches wide will be used, the duct will require a little more than ten widths, as shown by *a b c d e f h i j* in Fig. 80. All the corners on the entire duct should be double seamed, as shown by A and B in Fig. 81. In A is shown the single edge turned up on top and bottom, while on the 30-inch depth of the duct is added the double edge, as shown, which is closed, using the "dolly and mallet," as at B. At C is shown the standing seam taken through *r s* in Fig. 80 and riveted at intervals, as at *a* in diagram C in Fig. 81. This standing lock should be made about 1 inch high, notching out at the ends where the doubled lock B takes place, as shown at *b*, and turning over a lap on the ends, as at *c*.

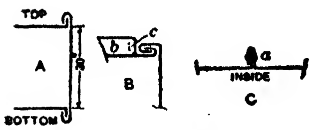


Fig. 81. Method of Locking Seams

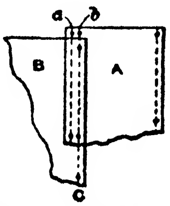


Fig. 82. Method of Laying Out Sheets

When laying out a large duct of this kind the floor is swept clean, a rough diagram made with chalk upon the same and the sheets dotted, as shown in Fig. 82, in which A is a sheet having a single and double edge and B a sheet having a single edge. The sheets are now laid one over another, so that the line *c* on the

sheet B meets the second line *b* on the sheet A, as shown. Of course the sheets should be made even at the ends, B being shown lower to indicate the method of lapping. When all the sheets are laid out to the required length of 31 feet, tack the sheets to the floor with roofing nails and draw out the full sized duct, allowing for and notching the laps for double seaming. The sheets must then be marked and bent up on the brake, being careful to have all the numbers toward one side. The duct is then put together at the building, using band iron hangers to fasten against the ceiling or wall. It should be understood that the 30-inch depth of the duct is a plain strip with the necessary edges allowed, while the top and bottom have the standing seams.

GALVANIZED IRON WORK FOR FAN SYSTEMS

This article will treat of various methods commonly employed in the construction of ducts and flues used with the fan systems of heating and ventilation, and will take up details of dampers, hangers, etc. Tables of the weights of round

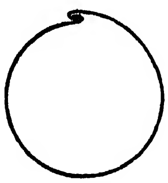


Fig. 83.

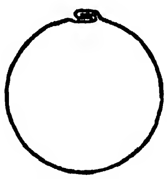


Fig. 84.

Longitudinal Seams

Fig. 85.

and rectangular pipes will be given, together with extracts from specifications dealing with gauges and methods of construction. Although such work is used chiefly with fan systems the following will apply equally well to large gravity systems:

Longitudinal seams in round or oval pipes are generally made with the usual lock edges, as shown in Fig. 83, on all gauges up to and including No. 20 iron. After the edges are locked the pipe is placed on a mandrel and the seam is set down with a hand groover of the proper size and is then set down flat with a hardwood mallet, making a finished seam, as shown in Fig. 84. The cost of these operations can be materially reduced if one of the various styles of hand or power machine groovers now on the market is used. Pipe jointed in this manner meets all the requirements of a first class job and does not need additional soldering.

Piping of No. 18 and heavier gauges should be made with riveted lap joints. Rivets should be spaced about 2 or 2½ in. on centers, and buttoned down on surface of metal with a rivetset of proper size. The total lap should never be less than 1 in., as shown in Fig. 85.

Figs. 86 and 87 show two methods of making joints in round or oval piping, and can be either soldered or riveted, as desired. Fig. 86 shows a single bead on

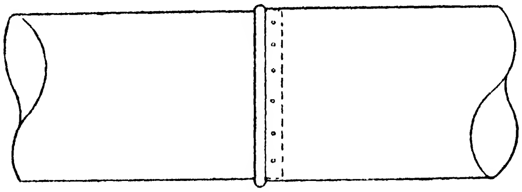


Fig. 86

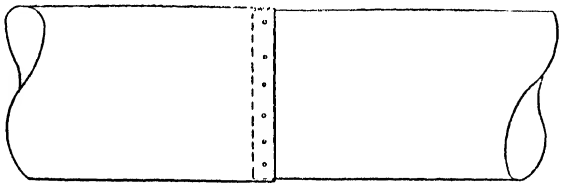


Fig. 88.

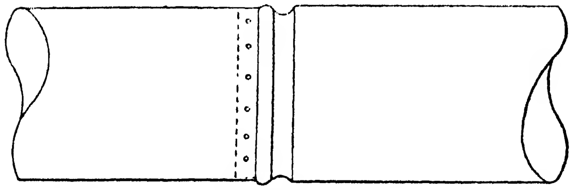


Fig. 87.

Joining Round Pipes

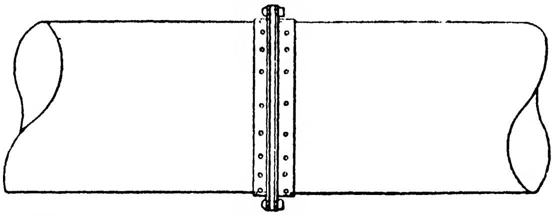


Fig. 89.

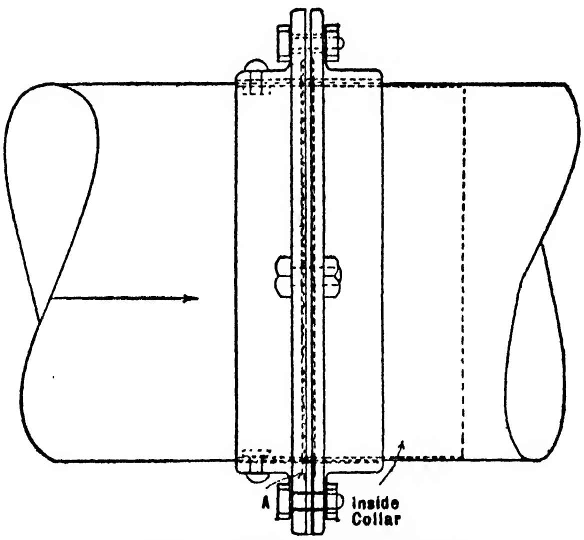


Fig. 90. Special Coupling Flange

the small end of the joint, which is made to fit snugly in the large end of adjoining joint of pipe. Fig. 87 shows a bead on the small end of joint fitted to the large end of the adjoining joint. These beads serve to stiffen the pipe, and sometimes several are used close together for this purpose.

Fig. 88 shows a plain lap joint, having a lap of about 2 in., and can be either soldered or riveted, or both, as required. Joints are marked out, allowing for an outside diameter on small end of joint and inside diameter on the large end of joint. When the proper allowance is made the small end should make a tight joint with the adjacent one, when the lap allowed has been reached.

Fig. 89 shows a method of using either cast or wrought angle iron flanges in making up joints on piping of heavy gauges or piping run in a vertical position on the exterior of a building. Angle iron flanges are generally riveted on each end of a length of piping, about 12 or 14 ft., which has intermediate riveted lap joints.

Fig. 90 shows a special flanged connection used on work that must be absolutely tight. Special angle flanges are recessed at A to receive the ends of the pipe section, which are flanged over. A collar about 3 in. long, made of a straight

piece of iron rolled to diameter of the flange, is riveted to the small end of the pipe and extends beyond the joint. Such joints are used on pressure work, but are not required for ordinary heating and ventilating systems.

Elbows should have the internal radius at least equal to the diameter of the pipe with which they connect. Even in the smaller sizes they should be made up

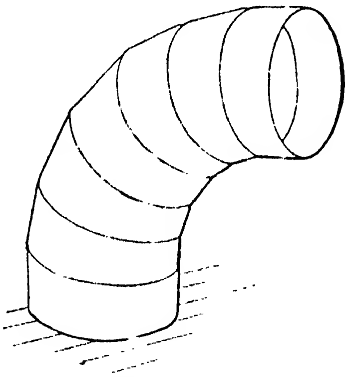


Fig. 91. Perspective of an Elbow

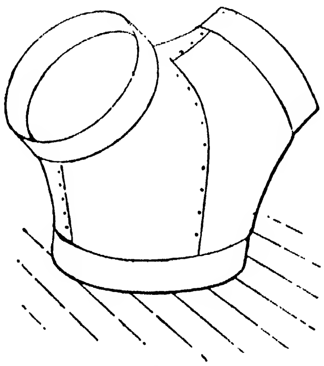


Fig. 92. Perspective of a Branch

of not less than five pieces, those above 8 in. usually having seven pieces. See Fig. 91. All elbows, except those of No. 18 gauge and heavier, are grooved and locked. Heavier elbows are riveted and soldered.

In blower work of good construction the branches are carefully designed somewhat as shown in Fig. 92.

Tapers to reduce from one size to another are generally made in a length of not over 36 in. They are either straight or offset to suit conditions.

Longitudinal seams on rectangular piping are made in various ways, and should be modified to meet the conditions of cutting sheets to make the various sizes of piping, also to suit the means of handling various sizes of piping in the shop.

Fig. 93 shows one of the most common ways of making a longitudinal seam. This is done by bending the single edge at right angles to the piping. The double edge is turned over and locked over the single edge, and the single and double edges are then bent over flat as shown.

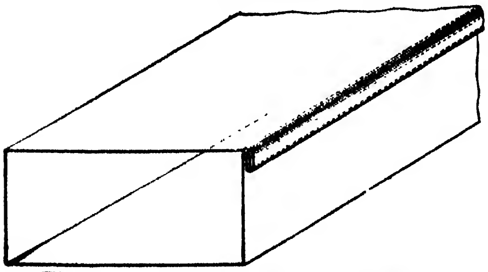


Fig. 93. Longitudinal Double Seam

Fig. 94 shows another method of making longitudinal seams, which is very popular in many shops; this is simply the ordinary grooved seam, and can be located at whatever point desired. This is an advantage, since the sheets can then be cut with a minimum of waste material. The seam is made in the manner described for round pipes. Where a hand or power machine groover is available, these joints can be made

very quickly and at small cost, especially when piping is made up in 8′ 0″ joints. When large sizes of pipes are to be shipped to a distance, they can be made up in this manner, with seams left open during shipment to be put together by hand on the job. This facilitates handling, permits nesting during shipment and saves in the cost of transportation. Less damage is likely to occur during shipment than where the pipe is shipped made up. It is to be understood that the groove seam is often made the reverse of this; which is to say, on the inside of the pipe. This seam is made by pounding the lock into a groove in a suitable mandrel, familiar to all. Sheets can be taken from the bundle of iron, squared up in the shears and then taken to the cornice brake and edged on both sides, also making the right

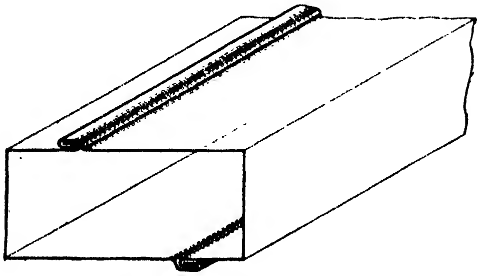


Fig. 94. Longitudinal Grooved Seam

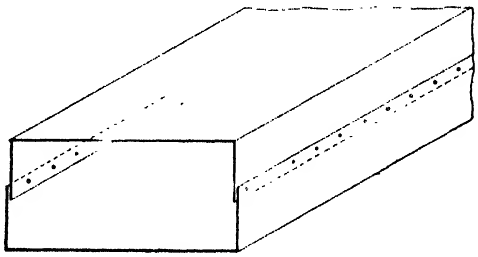


Fig. 95. Longitudinal Riveted Seam

angle bend all at one handling. This method can be used on all gauges up to and including No. 18, if the iron used is of a good grade. If poor iron is used it often cracks at the seam.

Fig. 95 shows the method of making longitudinal seams on piping of heavy gauges. They are ordinary lap seams and can be placed in almost any position.

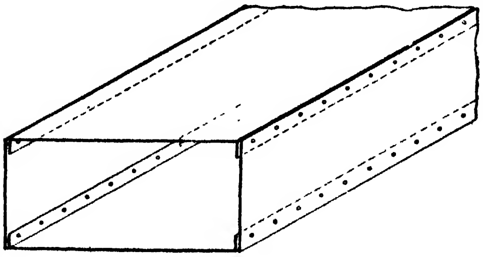


Fig. 96. Longitudinal Riveted Corner Seam

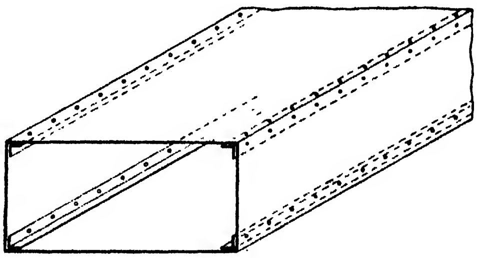


Fig. 97. Longitudinal Corner Seam With Angles

The lap on these seams should never be less than 1 in. and rivets spaced about 2 or 2½ in. on centers, and in about ½ in. from side of sheet, making rivet line in center of lap. When an especially neat job is required, regardless of expense, it is probably better to make the lap at the corners of the pipe, as shown in Fig. 96, and place the lap on the inside. The raw edge of metal can be rounded over the corner, making a very neat and serviceable job. Riveted joints should be made

up very carefully and rivets buttoned down on the metal with a rivetset of the proper size.

Fig. 97 shows a general method of constructing ducts of heavy plate metal when metal is most too heavy to make a right angle bend on a sheet of ordinary length. Angle irons about $1\frac{1}{2} \times 1\frac{1}{2} \times 3\text{-}16$ in. are cut the exact length of sheets, and about 9-32 in. holes punched about 3 in. on centers.

Fig. 98 shows a method of making up joints for the lighter gauges of iron, say

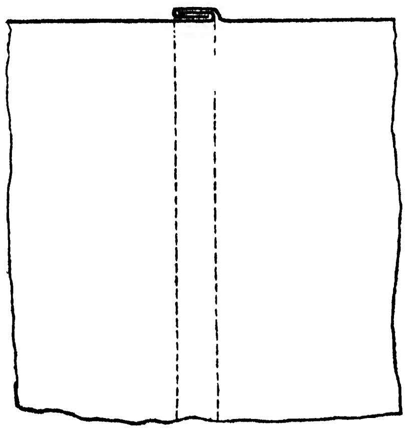


Fig. 98. Ordinary Cross Seam Joint

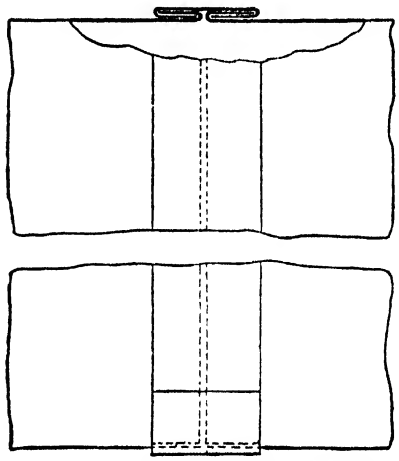


Fig. 99. Slide Joint by Means of a Slip

from No. 30 to No. 26, and is known as a double seamed joint. A single edge is turned up on one end of the joint of pipe, and a similar edge on the abutting end is slipped over it. Then both edges are brought over flat with a smooth mallet.

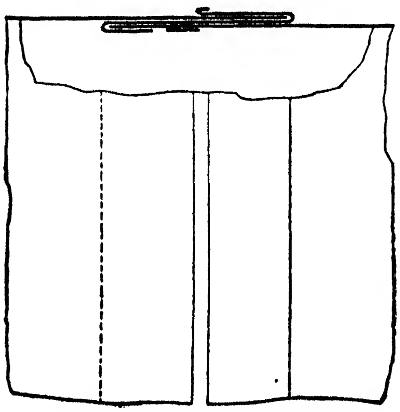


Fig. 100. Conventional Slip Joint

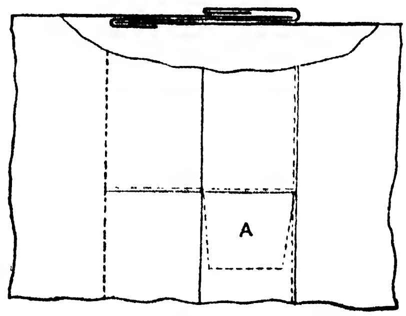


Fig. 101. Another Conventional Slip Joint

This seam should be dented by means of a good prick punch in order to avoid the joint slipping out while handling the finished length.

Fig. 99 shows a joint much used on good work and known as the slide joint. Edges are bent almost flat on the pipe, and a double edged flat piece is slipped

over these edges. This makes a very neat and serviceable job, and has the advantage of being utilized in almost any tight corner, besides enabling the duct or casing to be taken apart for cleaning.

Fig. 100 shows a form of slip joint used where particularly neat work is required. The slip proper is made up separate from the piping, and outside edge wired with about 3-16 or ¼-in. round rod, then formed up with solid corners and riveted to small end of the duct, where provision has been made for its reception by cutting out the corner of the duct for the length of the slip. Then the large end of adjoining joint is placed into this slip as shown. Slips of this character should not have less than 2-in. lap, and outside section of slip should be about 1 in. wide.

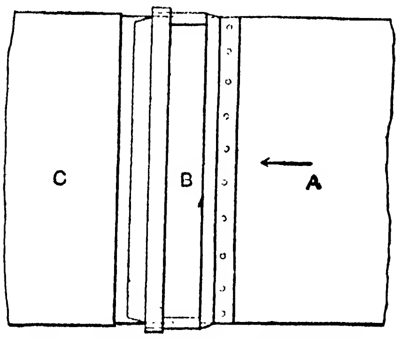


Fig. 102. A Simple Slip Joint

Fig. 101 shows the same pattern of slip joints as the foregoing, but without the wired outside edge, and in place of it a hem edge turned inside of slip, thus doing away with the raw edge of metal that would otherwise be exposed.

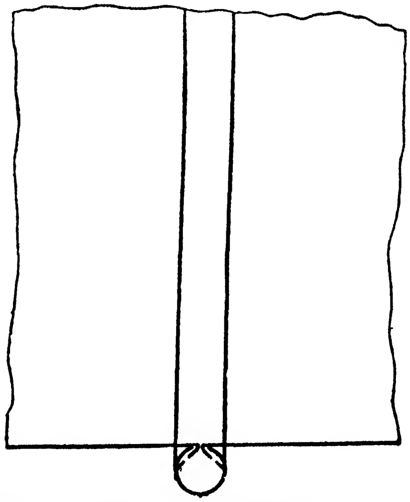


Fig. 103. Slip Joint for Neat Appearance

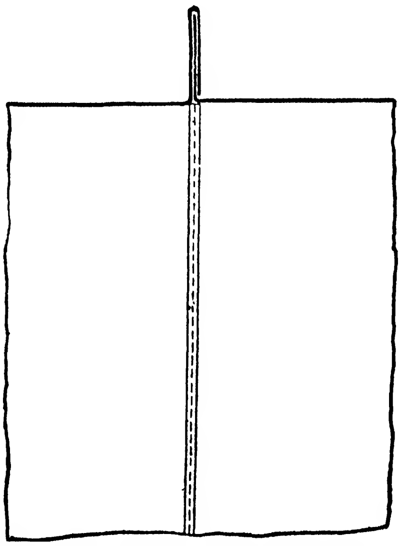


Fig. 104. Standing Seam Slip Joint

Fig. 102 shows a joint used by some blower manufacturers for their rectangular ducts. The sleeve B, into which the end of section C slips, is about 2 in. long. This joint gives the appearance of good workmanship in a system of ducts connected by this method.

Fig. 103 shows a method of making up joints, that has been used where a very neat job is desired. About ⅜-in. edges are bent up at an angle of 45 degrees on

large and small ends of the piping. They are then placed together and a ½-in. brass tube previously slotted is slipped over the edges, mitering the corners of the tubing. This method of making joints is often used for cylinder lagging.

Figs. 104 and 105 show a joint used on large rectangular piping. This joint is practically a standing seam joint, makes a strong, firm joint and also serves to

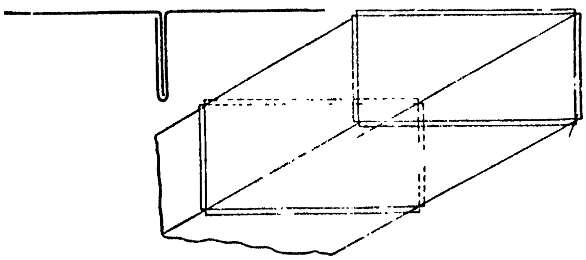


Fig. 105. General View of Standing Seam Joint

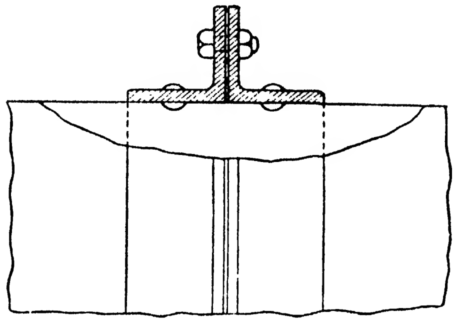


Fig. 106. Cross Joint by Means of Angle Irons

stiffen the piping. When these joints are made about 36 in. long they make a very rigid length of piping without the additional bracing generally necessary on piping of large sizes. The joint is made by bending a single edge about 1 in. at right angles to the side of the piping, and on the adjoining edge a double edge is bent, bending down nearly tight on three sides of the duct, allowing one side open in order to slip single edge into position. Then all sides are gone over and hammered down tight and riveted or bolted through the standing lock.

Fig. 106 shows angle irons arranged to make a joint between lengths of piping. The angles should be either 1, 1¼ or 1½ in., according to the size of the pipe. They should be riveted securely, making either a miter or butt joint on the corner of the piping.

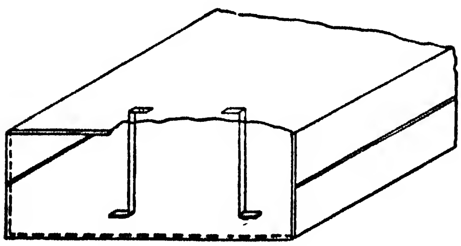


Fig. 107. Band Iron Braces

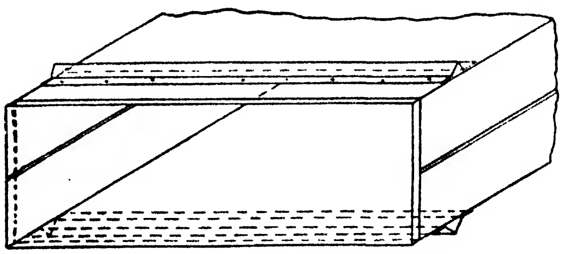


Fig. 108. Sheet Metal Braces

On rectangular ducts having a width of about 30 in. or over it is generally necessary to provide some means of bracing the wide sides of the ducts. Fig. 107 shows a popular and cheap method of bracing with bar iron braces, suitable to use on ducts up to 36 in. wide. Braces can be made of about 1¼×3-16 in. bar iron

and bent up in Z form, as there is no tendency for the brace to turn sideways. Only one rivet is used on each end in riveting to duct.

Fig. 108 shows a method of bracing ducts by means of bent strips of about No. 18 iron, riveted to the ducts as shown.

Fig. 109 shows a duct braced with angle iron, which makes a thoroughly substantial job. Angle iron should not be less than $1 \times 1 \times 1/8$ in. on ducts up to 40 in. wide, and using larger angle iron on sizes above this. Rivets should be spaced about 6 in. on centers and braces spaced about 32 in. apart.

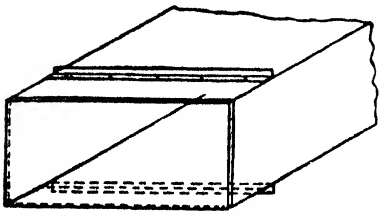


Fig. 109.
Angle Iron Braces

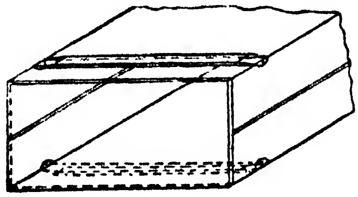


Fig. 110.
Incased Wood Braces

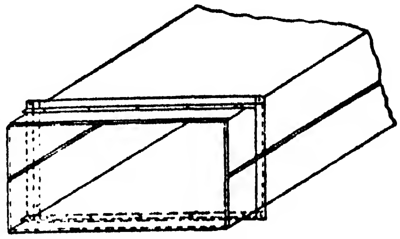


Fig. 111.
Complete Angle Iron Braces

Fig. 110 shows a method of using wooden strips incased in galvanized iron and fastened to the ducts by wire nails, clinched on the inside. Strips of hemlock or almost any soft wood, about $2\frac{1}{2} \times \frac{7}{8}$ in., with the ends tapered wedge shaped for a distance of about 4 in., are completely incased in a covering of about No. 26 galvanized iron, allowing a small tab for riveting to the side of the duct at each end of the brace. The rough edges of the iron are left on the under side of the brace, which is then set on the duct and 3-in. wire nails are driven through the brace and duct, then clinched over by the helper on the inside. This makes a cheap form of bracing, but is barred out by many specifications.

Fig. 111 shows a very good method of bracing rectangular ducts, and can be used on all sizes. Angle irons are cut for all sides, and an allowance equal to the width of the angle iron is made on each angle on each end. By setting angle irons on adjacent sides of the duct in an opposite position, you have angle irons meeting back to back at the corners, then having a hole in each, they can be bolted or riveted together, forming a complete frame around the duct. This feature is made use of in erecting them on a length of piping, as the necessary number of braces can be bolted around the piping, then all riveted to the piping at one time, thereby saving labor in handling. Angle irons should be $1 \times 1 \times \frac{1}{8}$ in. on smaller sizes of piping requiring bracing and $1\frac{1}{4} \times 1\frac{1}{4} \times$ 3-16 in. on ducts of larger dimensions. Space rivets about 6 in. on centers and space braces about 32 in. on centers. Fig. 112 shows a method of joining corners of this brace in larger detail.

Transformation pieces are made in a variety of forms from rectangular to square or to a rectangular shape of different dimensions. It is important in the case of the latter that the piece be of ample length, so that the change from one shape to another will not be too abrupt, thus interfering with the passage of air. A transformation from rectangular to round is shown in Fig. 113.

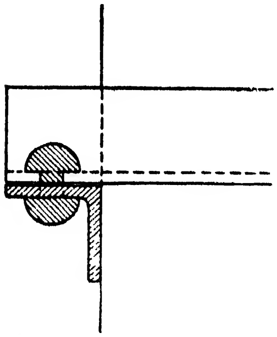


Fig. 112. Detail of Corner of Angle Iron Braces

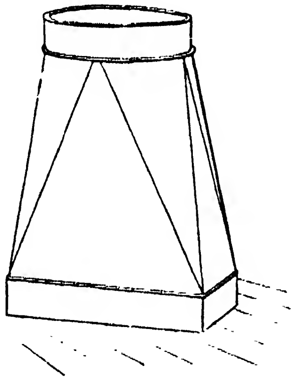


Fig. 113. A Transforming Piece

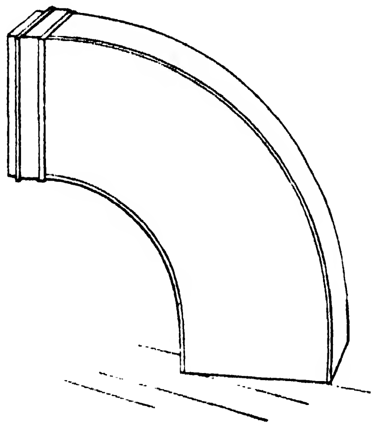


Fig. 114. Rectangular Square Elbow

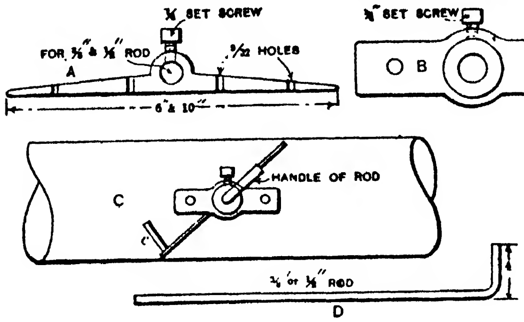
In making rectangular bends it is always advisable to make them as easy as possible. Good practice determines that bends shall have an inner radius or radius in the throat equal to the diameter of the side of duct in the direction of the bend as shown in Fig. 114.

Dampers for controlling the flow of air should be placed in all branch pipes and connections, for in all heating and ventilating work it is impossible to foresee all conditions that may arise in erecting a piping system. Adjustable dampers must be used to secure the desired distribution.

Fig. 115 shows an approved form of adjustable damper and fittings which can be used on round or rectangular ducts. Damper braces are made of cast iron and holes for riveting to the damper and for the damper rod are cored in the casting. The top of the brace is tapped out to receive a set screw for setting down on the damper rod. Screw castings are cast with a hole for the damper rod and holes for riveting to the ducts are cored in the casting, and the hole is tapped out to receive a set screw for adjusting the damper. The damper rod is made from stock wrought rod and generally made 3/8 in. in diameter for small dampers and about 1/2 in. for large dampers. Damper braces are also made in two sizes, for large and small dampers.

Deflecting dampers are commonly used in ducts, at branches. These are commonly called switch dampers and the type is illustrated in Fig. 116.

In factory buildings of slow burning construction, hangers can be made up as shown in Fig. 117, when the ducts run at right angles to the floor beams. Where piping runs parallel to the floor beams a straight hanger of bar iron can be used by bending about 4 in. of the bar at right angles and fastening to the tongued and grooved flooring by at least two lag screws. This type is shown in Fig. 118.



A BRACE FOR LARGE DAMPER
B " " SMALL "
C DAMPER IN ROUND PIPE
c STOP TO PREVENT DAMPER CLOSING OTHER WAY
D DAMPER ROD

Fig. 115.

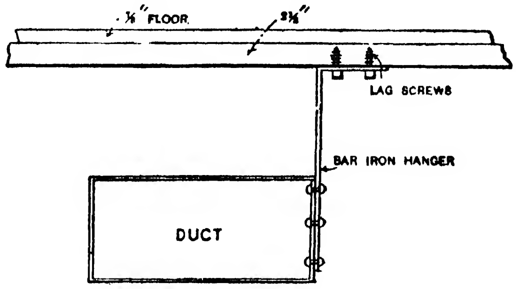


Fig. 118.

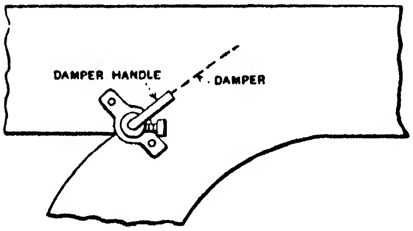


Fig. 116.

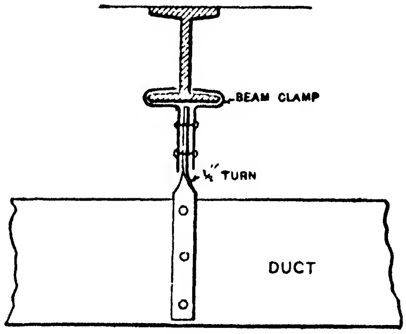


Fig. 119.

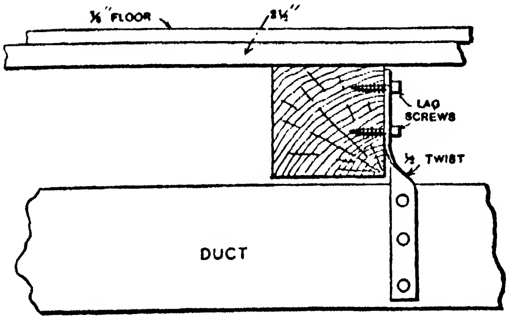


Fig. 117.

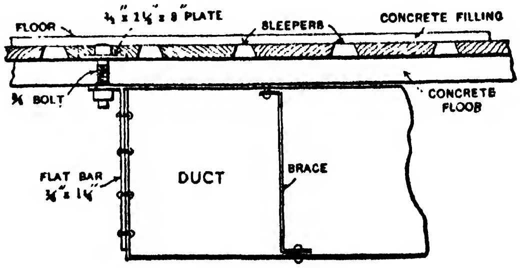


Fig. 120.

Types of Dampers and Hangers for Air Ducts

In buildings of fireproof construction, when the piping runs at right angles to the floor beams, a hanger of the type shown in Fig. 119 may be used to good advantage. One half of the beam clamp can be made as part of the hanger and the remaining half of the clamp made up and bolted fast. Fig. 120 shows one method of hanging ducts from a concrete floor. The vertical irons riveted to the sides of

the ducts are turned at right angles at the top and are drilled to receive the bolts passing down through the floor.

ESTIMATING THE WEIGHTS OF RECTANGULAR AND ROUND PIPING AND SPECIFICATIONS

As to gauges of galvanized iron commonly used, the following are taken from a United States Government specification:

Round pipes up to 13 in. in diameter................No. 24 gauge

Round pipes 14 to 30 in. in diameter................No. 22 gauge

Round pipes 31 to 48 in. in diameter................No. 20 gauge

The following are taken from the specifications of prominent engineers:

Round pipes smaller than 12 in......................No. 26 gauge

Round pipes 13 to 20 in.............................No. 24 gauge

Round pipes 21 to 24 in.............................No. 23 gauge

Round pipes 25 to 30 in.............................No. 22 gauge

Round pipes 31 to 44 in.............................No. 20 gauge

Round pipes 45 in. and larger.......................No. 18 gauge

Round pipes smaller than 26 in..............Nos. 24 or 26 gauge

Round pipes 26 to 36 in.............................No. 22 gauge

Round pipes 37 to 48 in.............................No. 20 gange

Round pipes 49 in. and larger.......................No. 18 gauge

One prominent blower company uses these gauges:

Round pipes 3 to 8 in...............................No. 28 gauge

Round pipes 9 to 14 in..............................No. 26 gauge

Round pipes 15 to 20 in.............................No. 25 gauge

Round pipes 21 to 26 in.............................No. 24 gauge

Round pipes 27 to 35 in.............................No. 22 gauge

Round pipes 36 to 46 in.............................No. 20 gauge

Round pipes 47 to 60 in.............................No. 18 gauge

Round pipes 60 in. and larger.......................No. 16 gauge

The accompanying table, Fig. 121, is of immeasurable value for quickly figuring weights of rectangular piping. It is to be understood though, that one gauge only is given for each size.

The weight of elbows, agreeing to the gauges represented for the rectangular piping, can be estimated quickly by computing the weight of a length of straight pipe equal to that of the center line of the elbow.

The weight is given in pounds per running foot, and the table covers all sizes from 2×2 in. to 60×60 in. The outer lines of figures are dimension figures; all other figures denote weights in pounds. It is obvious that all pipes having the same circumference must be of the same weight, provided, of course, that they are made of the same gauge of metal. Therefore, to avoid a repetition of figures and in consequence, considerable confusion, diagonal lines are drawn across the sheet, each line representing a certain weight, which weight is indicated at each end of the line at intervals throughout its length.

To find the weight of a rectangular galvanized iron pipe of any size, find one dimension in inches in one of the horizontal (top or bottom) lines of figures, and the other dimension in one of the vertical side lines of figures; at the intersection of the columns headed by these figures will be found either a figure denoting the weight in pounds per running foot or a diagonal line which, when followed, terminates in a figure denoting the weight. For example, let it be required to find the weight per foot of a pipe 16×24 in. Find in the upper line the figure 16 and in the side line the figure 24, follow the columns and the space at their intersection is found to be crossed by a heavy diagonal line; follow this line in either direction and the figure 12.9 is found, which denotes the weight in pounds per running foot.

The diagonal lines are made alternately heavy and light to aid the eye in following them. This table has been in use for a number of years by one of the larger blower companies, and has been found in practice to agree closely with the weight of metal used in actual installations and it has also been recommended for its accuracy by readers of aforesaid journal.

The following gauges are represented: From 2×2 in. to 6×6 in., No. 26; from 7×7 in. to 12×12 in., No. 24; from 13×13 in. to 20×20 in., No. 22; all above 20×20 in., No. 20. This represents about the average of the gauges used for fan work, the larger sizes requiring internal bracing. An allowance has been made for seams, laps, sleeves, rivets and solder, and waste when pipes are made from sheets 30×96 in. Reverting to what was previously stated in the matter of gauges, it is to be remembered that these weights may be readily converted into other gauges by using the usual factors.

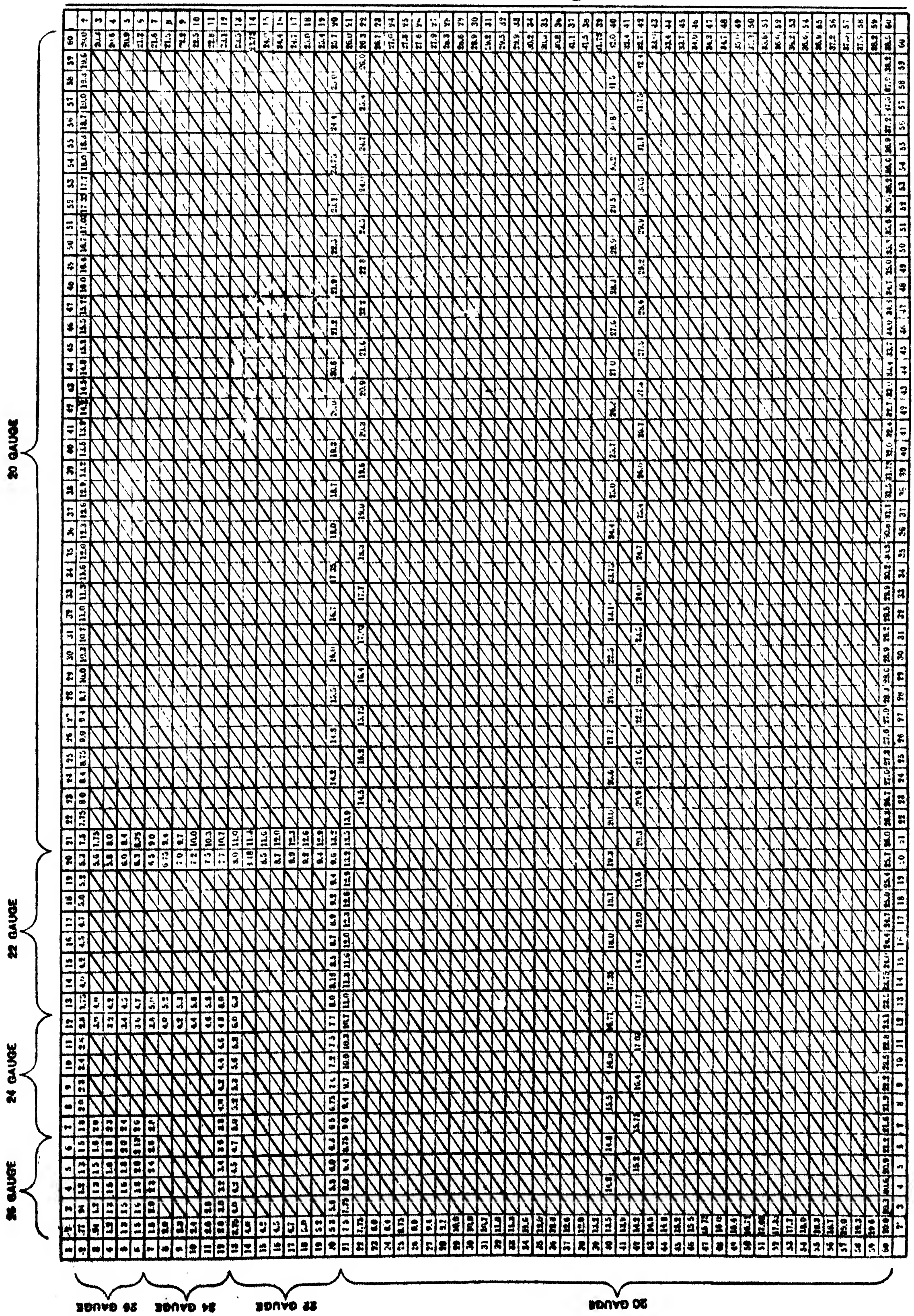


Fig. 121. Chart for Ascertaining Weight of Rectangular Galvanized Iron Pipe

The following table is reprinted from the book, "Furnace Heating":

TABLE I—WEIGHT OF GALVANIZED IRON PIPE, THE AREAS AND CIRCUMFERENCES OF CIRCLES

Diameter Pipe Inches	Approx. area Sq. Inches	Circumference Inches	Weight of pipe per running foot: No. 28 gauge	No. 26 gauge	No. 24 gauge	No. 22 gauge	No. 20 gauge	No. 18 gauge	No. 16 gauge
1	0.7854	3.14	....	....	....	....	....	....	....
2	3.1416	6.28	....	....	....	....	....	....	....
3	7.07	9.42	0.7	....	....	....	....	....	....
4	12.57	12.56	1.1	....	....	....	....	....	....
5	19.64	15.70	1.2	1.4	1.8	....	....	....	....
6	28.27	18.84	1.4	1.7	2.1				
7	38.49	22.00	1.7	2.0	2.5	The heavy faced figures indicate the weight of pipes commonly built of the gauge stated at the head of the column in which they occur.			
8	50.27	25.13	1.9	2.2	2.8				
9	63.62	28.27	2.1	2.4	3.1				
10	78.54	31.41	2.3	2.7	3.4				
11	95.03	34.55	....	2.9	3.7				
12	113.10	37.70	....	3.2	4.1	....	....	....	....
13	132.73	40.84	....	3.4	4.4	....	....	....	....
14	153.94	44.00	....	3.7	4.7	....	....	....	....
15	176.72	47.12	....	....	5.0	6.1	....	....	....
16	201.06	50.28	....	....	5.4	6.5	....	....	....
17	226.98	53.41	....	....	5.7	6.9	....	....	....
18	254.47	56.55	....	....	6.0	7.3	....	....	....
19	283.53	59.69	....	....	6.3	7.7	....	....	....
20	314.16	62.83	....	....	6.8	8.2	....	....	....
22	380.13	69.11	....	....	7.3	8.9	....	....	....
24	452.39	75.39	....	....	8.0	9.7	11.5	....	....
26	530.93	81.68	....	....	8.7	10.6	12.4	....	....
28	615.75	87.96	....	....	9.4	11.4	13.4	....	....
30	706.86	94.24	....	....	10.0	12.2	14.4	18.7	....
32	804.25	100.53	....	....	....	13.0	15.3	20.0	....
34	907.92	106.81	....	....	....	13.9	16.3	21.2	....
36	1017.88	113.00	....	....	....	14.6	17.2	22.4	....
38	1134.12	119.38	....	....	....	15.5	18.2	23.7	....
40	1256.64	125.66	....	....	....	16.2	19.1	24.9	30.7
42	1385.45	131.94	....	....	....	....	20.1	26.1	32.2
44	1520.53	138.23	....	....	....	....	21.0	27.4	33.7
46	1661.91	144.51	....	....	....	....	22.0		35.2
48	1809.56	150.79	....	....	....	....	22.9	29.8	36.7
50	1963.50	157.08	....	....	....	....	23.9	31.0	38.2
52	2123.72	163.36	....	....	....	....	....	32.2	39.7
54	2290.23	169.64	....	The diameter squared ×0.7854=area of a circle				33.6	41.4
56	2463.01	175.93	....	....	....	....	....	34.9	43.0
58	2642.09	182.21	....	The diameter ×3.1416=circumference of a circle				36.1	44.5
60	2827.74	188.49	....	....	....	....	....	37.4	46.0

Weight of Galvanized Iron Sheets in pounds per square foot, United States Government Standard

Gauge	28	26	24	22	20	18	16
Weight in pounds	0.78	0.91	1.16	1.41	1.66	2.16	2.66

In regard to rectangular pipe, custom varies considerably in the gauges used; if properly stiffened, lighter gauges may be used than for round pipes of the same area.

The following is taken from a United States Goverment specification: Rectangular ducts not exceeding 40 in. in width are to be made of No. 24 gauge; those wider than 40 in. to be made of No. 20 gauge. All surfaces of ducts 24 to 39 in. wide are to have V-shaped stiffening ribs, riveted in place outside of the ducts, spaced not over 30 in. apart. All ducts having a surface of 40 in. or over in width or depth must have 1×1×3-16 in. angle iron frames around them riveted to the ducts and spaced not over 30 in. apart. The ends of the various sections of ducts

are to be finished with $1\frac{1}{4} \times 1\frac{1}{4} \times \frac{1}{4}$-in. angles. All ducts must be practically airtight when finished.

A specification for one of the largest department stores in the country states: Galvanized iron ducts 4 ft. square and greater are to be made of No. 22 gauge, smaller ones of No. 24 gauge. All joints are to be riveted airtight. All stiffening frames are to be of angle iron, painted. No wood construction allowed. Ducts must be thoroughly stiffened with 1-in. angle irons spaced not more than 4 ft. apart.

WEIGHTS AND THICKNESSES OF AMERICAN TIN PLATES

It is of interest to compare the weights of galvanized sheets stated in Table I with those of tin plates given in Table II, which is reprinted from *Metal Worker*.

TABLE II—WEIGHTS AND THICKNESSES OF TIN PLATES

Denomination Pounds	Weight per box of 112 sheets, 14×20 inches—Pounds	Approximate weight per square foot in decimals of pound	Thickness in decimals of an inch
55	55	0.252	0.00625
60	60	0.275	0.00638
65	65	0.3	0.0075
70	70	0.321	0.008
75	75	0.344	0.0086
80	80	0.367	0.0092
85	85	0.39	0.0098
90	90	0.42	0.0105
95	95	0.436	0.0109
100	100	0.46	0.0115
IC	108	0.5	0.0125
IX	136	0.625	0.0156
IXX	156	0.71	0.0178
IXXX	176	0.8	0.02
IXXXX	196	0.9	0.0225
IXXXXX	216	1	0.025

FINDING TRUE ANGLES IN BLOWER CONNECTION

In Fig. 122 is shown the side and plan views of two fan collars connected to one discharge pipe, and it is desired to find the true angle of the Y and the elbows. The size of the fan collars indicated by H and H in plan and H^1 in side view is to be as indicated, connecting to an 18-inch round pipe in the form of two elbows, as shown in plan, which in turn connect to a 25-inch pipe by means of a Y. The large discharge pipe passes through the wall at an angle of 54 degrees. The distance from the fan collar to the wall is 4 feet 6 inches and the hight from the bottom of the collar to the opening in the wall 3 feet 2 inches. The distance between the inside of the two fans is 2 feet, as shown in plan.

Having drawn the side and plan views in their proper relative positions, as shown, the true angle of the Y is obtained as follows: Draw the center line through the side view, as shown by the dotted line *r n f v*; also the center line in plan, as shown by *n i d c*. From *n* in elevation drop a vertical line intersecting the center line *y n* in plan at *i*; also from *f* in elevation drop a vertical line cutting the center lines in plan at *d* and *s*.

Parallel to *r n*, in side view, draw any line, as D E, which intersect by a perpendicular dropped from *f* at E. Take the distance from *s* to *d* in plan and place it, as shown, from E to *d'* and from E to *d''*. From *n* in side view, perpendicular to E D, draw a line intersecting E D at B. From B draw lines to *d'* and *d''*. Then will D B *d'* and D B *d''* be the center lines of the Y. On either side of D B place one half of the 25-inch pipe and on either side of the center lines *d''* B and *d'* B place one half of the 18-inch pipes until the sides of the pipes intersect, as shown, which gives the true angles. The pattern for this Y must be developed by triangulation.

To obtain the true angle of the elbow shown by *f v* in side view and *d c* in plan proceed as follows: From *v* and *f* draw horizontal lines, as shown, intersecting the perpendiculars dropped from *f* and *n*. At right angles to *d i* in plan draw *i n''* equal in hight to *b n* in side view. Then *d n''* in plan shows the true length of *d i*.

Take the distance from *c* to *i* in plan and place it on the horizontal line shown by *c' i'* in (T). From *i'* erect the perpendicular *i' n'* equal to *m n* in side view and draw the line *n' c'* in (T). At right angles to *c d* in plan erect the perpendicular *d f''* equal to *e f* in side view. Then *f'' c* in plan is the true length of *d c* in plan.

With radius equal to *c f''* in plan, and *c'* in (T) as center, describe the arc *f'*, which intersect by an arc struck from *n'* as center and *n'' d* in plan as radius. Then *n' f' c'* in (T) is the true angle of the center line at point *d* in plan or at *f* in side view. If it is desired to place an elbow between the points *f* and *v* in side view, draw a graceful curve between the points M L and N O in (T), as shown, at a distance of 9 inches on either side of the points *f'* and *c'*, and make the elbow L M N O into any desired number of pieces. A slip joint is placed between *a* and *b* in side view to allow the work to be fitted as desired.

PUNCHING SHEET IRON

All who have made riveted smoke stacks, furnace drums or other heavy sheet iron work, have had more or less trouble in getting the holes in the two ends of the

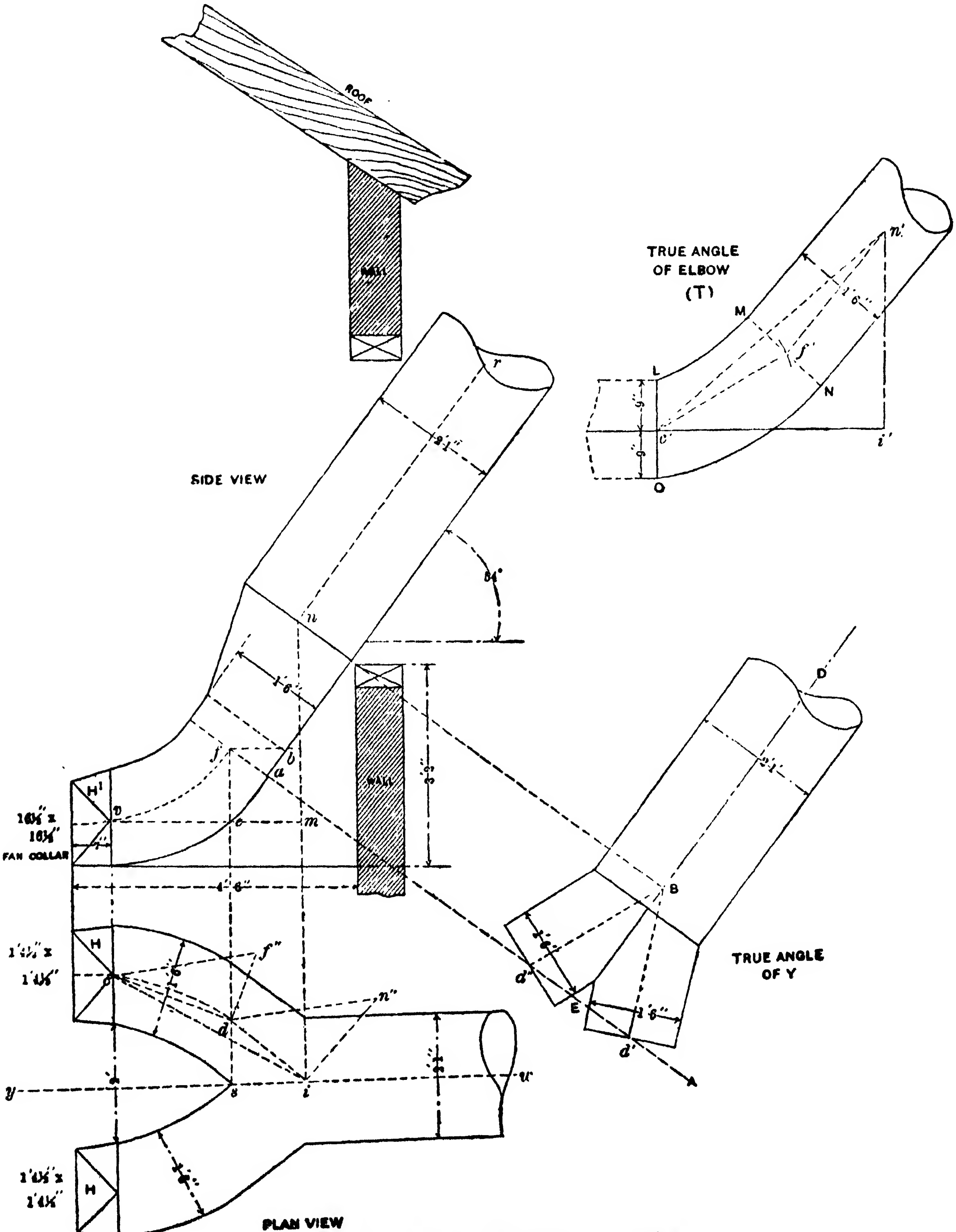


Fig. 122. Method of Finding True Angles

sheet so that they would match perfectly. If punched on a lead cake or nut the punch is likely to get off of the mark that has been made with the template, and when the time comes to do the riveting a great deal of labor is spent in reaming the hole so that the rivet will enter. This method of punching also raises a burr that must be flattened down when the rivet is in place, or before it is inserted, if a neat flat tight seam is desired. A good workman has often longed for a gang punch when he has had a lot of such work to do. The device shown in Fig. 123 has been in use in the sheet iron shop for punching heavy sheet iron work. It consists of a heavy casting with lugs cast at each end, as shown. This serves as a bed plate and is drilled at proper intervals with ½-inch holes. On the top of this bed plate arrangement has been made to secure steel plates by means of set screws.

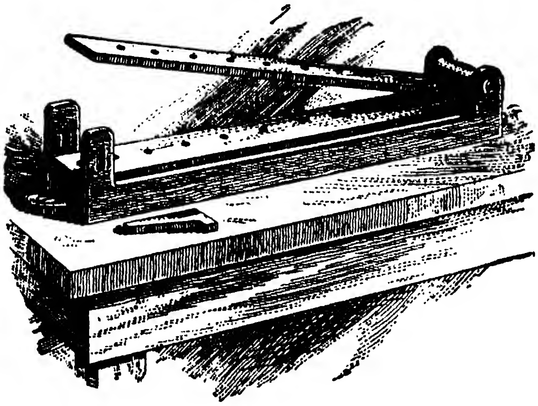


Fig. 123. A Device for Punching Sheet Iron

These steel plates are drilled with holes of different sizes to suit the punches used for different sizes of rivets. The lugs at each end of the bed plate serve to form a hinge for templates which correspond with the holes in the steel plates used. This template shuts down accurately over the holes in the steel plates and on top of the iron to be punched. It is secured in place by a wedge pin, which is driven in the oblong slots that are made in the lugs at the opposite end of the bed plate. By this means the iron is held from slipping while the holes are punched clean and accurately, so that when the sheet is formed the holes in the two ends match each other perfectly and there is no trouble in putting the rivets in them without reaming. After this is done it is simply a matter of labor with the heavy hammer to do the riveting.

LINING ELEVATOR BINS WITH HEAVY SHEET IRON

Herein it will be endeavored to tell the manner in which certain elevator bins were lined. These bins averaged from 8 ft. sq. to 15 ft. sq., and were constructed of timbers about 6 in. sq., laid on top of each other, and notched together at the intersection and doweled intermediately as indicated in Fig. 124. The bottoms of the bins were slanted in as indicated in Fig. 125. The bins were not all square

and the outlet *a*, Fig. 125, was not always in the center of the bin. There were a number of groups of different sizes and some were used for corn, others for wheat, etc. The grain is poured into the bins by being mechanically carried to the top of the building, where it is dumped into a weighing device, from which it flows into the bins. Outlet *a* is connected with a chute for drawing the grain from the bins, the chute being provided with a slide valve.

While the friction of the grain against the vertical sides of the bin is not suffi-cient to warrant lining it throughout the entire hight, the friction on the sloping parts of the bottom is so great that the woodwork is rapidly worn away. In order to prevent this wearing, the bin bottoms were lined with No. 16 galvanized iron. Owing to the variation in size and shape of the bottoms, it was impossible to order sheets of any special size that would facilitate the work and save material. The ron was therefore ordered in sheets 30 × 96 in., and it required over 700 sheets.

There was much discussion between the proprietors and the foreman as to the best methods of procedure, that is, whether it was better to have the material deliv-ered to the elevator, direct, and have all work done there, or to deliver it to the shop for preparation. It was finally decided that it would be better to measure the bins, numbering each one and lettering each side, and cut, punch and form the material at the shop, where the work would be under the supervision of the oreman, and where everything would be convenient and comfortable.

The bins were measured as follows, each one being treated separately and ndependent of any other. A plan and surfaces of the four sides expanded, as in-dicated in Fig. 126, were made of each bin. The bin indicated is No. 1. These sketches and dimensions were made in a notebook at the building from measure-ments of the woodwork, after the bin bottoms were complete ready for lining. A sketch drawn to 1½-in. scale was then made, showing what was roughly sketched in the notebook, and the lines *a*, *b*, *c*, *d* drawn on the expanded sides A, B, C, D, as indicated in Fig. 127. The material being 30 in. wide and 1 in. being allowed or laps, the lines *a*, *b*, *c*, were spaced 29 in. apart.

As there were to be a great many different sizes to lay out on the same floor pace, it was necessary to devise some way of doing it that would not require the mak-ing of lines on the floor, as the lines would soon become so numerous as to be con-fusing. A way was therefore schemed out, as indicated in Fig. 128. Lines *a a*, *b*, *c c*, *d d* and *e e* were chalk lines marked on the floor, and they were made bout 18 ft. long and just 29 in. apart. Two strips of metal were then cut 4 in. wide and 8 ft. long and joined together, making a straight strip 16 ft. long, as hown by *f*; four other strips of the same width were also cut and joined together

in pairs, making the two straight strips *g* and *h*. One inch from one edge of *g* and *h*, respectively, lines were struck, as indicated by *i* and *k l*.

In laying out one side of the bin take A, for instance. The 10-ft. dimension was laid off on line *a a*, as indicated at *m m'*. Straightedge *f* was then placed 6 ft. 4¼ in. from line *a a* and secured by nails tacked to the floor through each end. A trammel was then set to the 7 ft. 9 in. dimension, and from *m* and *m'*, as centers, arcs were struck against the edge of *f*, locating the points *n* and *n'*. The distance *n n'* should be just 12 in., and if a slight variation was found, the difference was distributed on each side, but it was found that when measurements were taken accurately there was hardly ever a discrepancy that amounted to anything. One of the other straightedges was then laid with its edge against *m* and *n* and tacked to the floor and the third straightedge laid against *m* and *n'* and tacked to the floor. Thus the surface outline by *m m'*, *n* and *n'* was an exact full size development of side, A, and the chalk marks *a a*, *b b* and *c c* were the line of the upper edge of the sheets.

The lines *i j* and *k l* struck on the straightedges *g* and *h* were the allowance for laps to be turned at the valley corners of the bins on opposite sides. Thus, sides A and C had laps on each side, while sides B and D were cut off on the line *m n* and *m' n'*.

After locating the straightedges the next step was to lay a sheet of iron in position at O, as indicated by the dotted lines. A straightedge was then laid on the sheet and brought even with line *m n*, and a line scribed across, which was where the sheet was to be bent at the valley. The straightedge was then pushed back 1 in. in line with *i j*, and the sheet scribed across for cutting. Another sheet, P, was then laid in position, overlapping O 1½ in. This sheet was similarly scribed on line *m'* and *n'* for bending, and on line *k l* for cutting. The piece P' which was thus cut off was then laid in position at Q, it having been turned over so that the miter line would just fit line *i j*, it then being only necessary to scribe line *m n* to locate the bend. Lines *m' n'* and *k l* were then struck and piece Q' was cut on *k l*, which was similarly turned over and placed in position R.

It will be seen that this completed side A, with the exception of the small corner R', which was cut from the scrap which fell from R. It will thus be seen that there was practically no waste of material.

All sides of all the bins were consecutively laid off and cut in this manner. Letters are used in describing the operation, but the pieces were marked 1 A 1, 1 A 2, 1 A 3, 1 A 4, 1 A 5, as shown, the first figure indicating the number of the bin, the letter indicating which side of the bin, and the last figure indicating the number and location of the piece of that particular side.

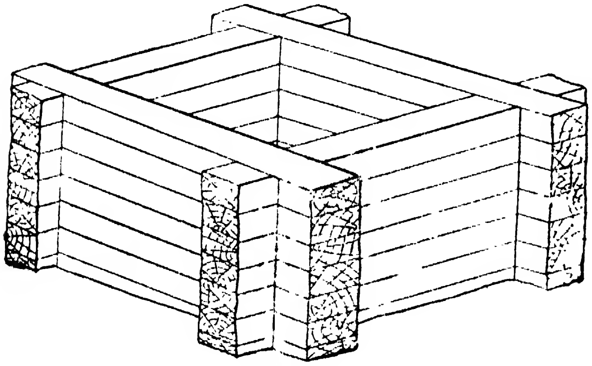


Fig. 124

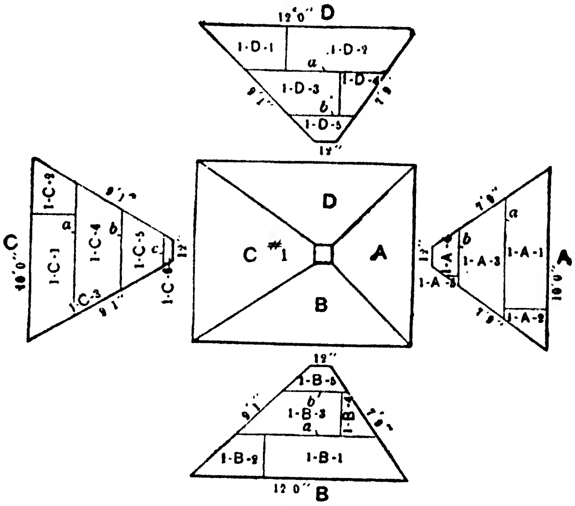


Fig. 127

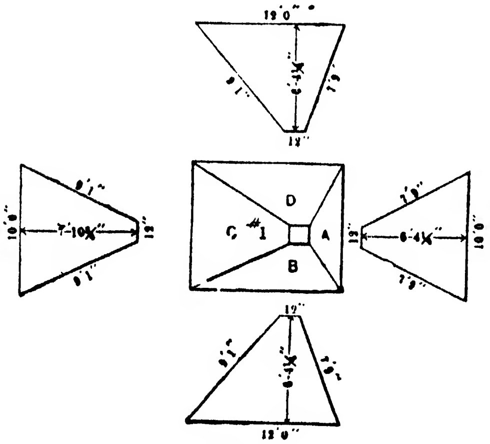


Fig. 126

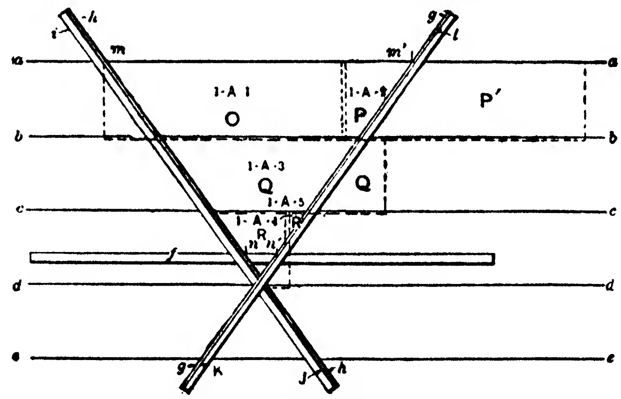


Fig. 128

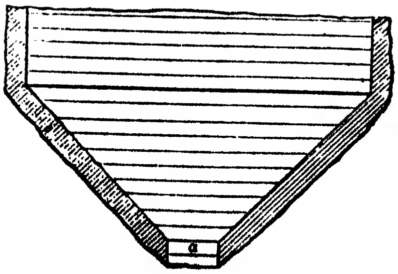


Fig. 125


Fig. 139

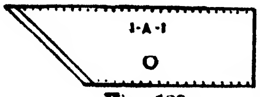


Fig. 129

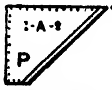


Fig. 130

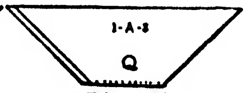


Fig. 131

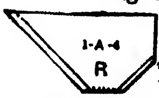


Fig. 132


Fig. 133

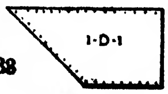


Fig. 134

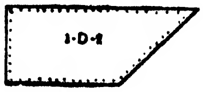


Fig. 135

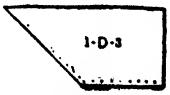


Fig. 136

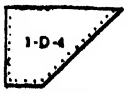


Fig. 137

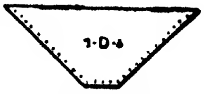


Fig. 138

Laying Out Galvanized Iron For Bin Bottoms

The straightedges were then shifted to form a full size outline of the next side of the bin—for instance D. As soon as a side was laid out so that the cross seams and number of pieces could be located and determined, they were properly marked on the scale drawing, Fig. 127. It will be seen that the expanded side A of Fig. 127 shows the number of pieces just laid out in full size, and is correspondingly marked. In laying out and cutting the material the edges which were to be punched for nailing, as described below, were also marked. The side of the metal on which the marking was done indicated that it was the upper surface. All marking was done with a solution of copper and acid.

After the different pieces were cut and identified by marking they were punched on one side and one end for nailing. The top courses were, of course, punched on both sides. Two-inch wire nails were used, spaced about 3 in. apart. Fig. 129 indicates how piece O (1 A 1) was punched; Fig. 130 indicates how P (1 A 2) was punched; Fig. 131 indicates how Q (1 A 3) was punched; Fig. 132 shows how R (1 A 4) was punched, and Fig. 133 shows how R′ (1 A 5) was punched. The upper edges and the straight ends of Q and R were not punched for the reason that it was found that while two thicknesses could not be pricked, a nail hole could be pricked through one thickness of the iron after it was laid in

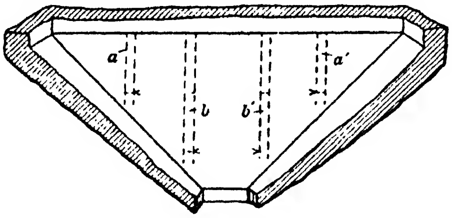


Fig. 140

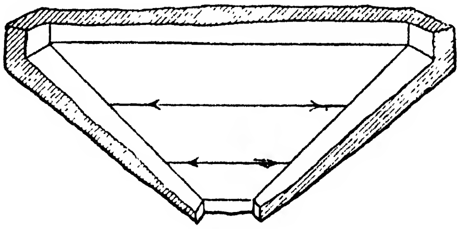


Fig. 141

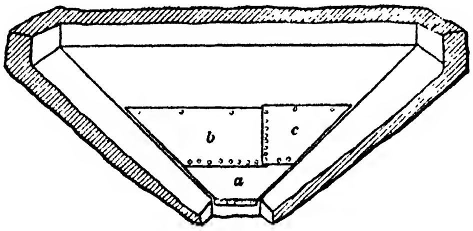


Fig. 142
Method of Laying Sheets in Bin

position on the solid heavy timbered bottoms of the bins, so that in laying the iron the unpunched edges were prick punched by means of a stout, well tempered sharp pointed punch and a heavy hammer, through the holes in the punched lower edges of O and Q, and square ends of P and R′, Fig. 128.

Referring to side D, Fig. 127, Fig. 134 indicates how piece 1 D 1 is punched. This piece is punched along its miter cut where it laps over and nails through the

1-in. lap edges turned on the miter pieces of sides A and C. Fig. 135 shows how 1 D 2 is punched; Fig. 136 shows the punching of 1 D 3; Fig. 137 shows the punching of 1 D 4, Fig. 138 shows the punching of 1 D 5. After being cut and punched, the miter pieces of the sides which carried the 1-in. laps along the valleys had this lap turned up a little more than half square, in the cornice brake.

When the material was ready it was sent to the building and nailed into the bins in the following manner: Two long strips of metal were provided, and marked as indicated in Fig. 139, the strips being about 1 in. wide and the spacings 29 in. apart. These strips were used to lay off the horizontal course lines, in the bins.

Referring to Fig. 140, which represents a sectional perspective view, looking into one of the bins, the strips were first laid in the position indicated by dotted lines *a* and *a'*, and marks made on the woodwork at the first 29-in. space, as indicated. The strips would then be shifted to *b* and *b*, and further marks made lower down on the wood surface, as indicated, and points marked on the wood from the spacing lines on the strips. In handling the strips they were kept rolled up except that portion which was to serve as a spacing measure.

Chalk lines were then struck through the points thus established on the woodwork, as indicated in Fig. 141. These lines determined the location of the upper edges of the sheets. It was then feasible to lay the smallest and lowest piece in position first and secure with a few nails in the upper edge, as indicated at *a*, in Fig. 142; then the second piece, *b*, was laid in position overlapping the first piece, and having the upper edge coincide with the second chalk line and secured with a few nails in its upper edge, as indicated. Piece *c* was then laid. All the sheets were thus nailed along the upper edges before the next and overlapping sheet was put in place, so that in case the grain should ever wear off the nail heads that projected up through, the sheets would not slip down, because of being secured by the nails in their upper edges, which were protected from the action of the grain by the sheet overlapping them. The next operation was to punch holes in the unpunched underedges, through the holes which were machine punched, and the nailing done. This process was repeated with the other courses until the top of the bin bottom was reached.

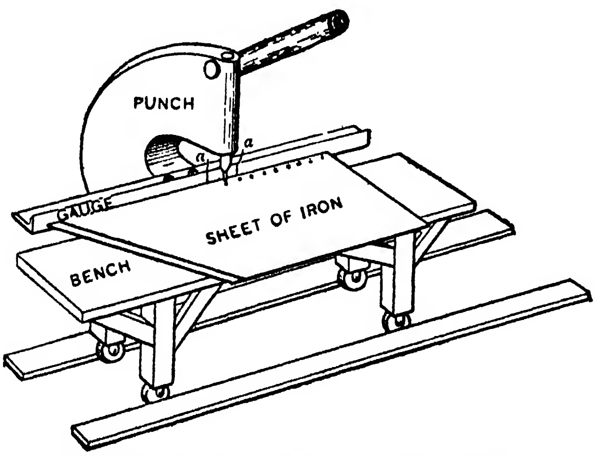


Fig. 143. Method of Punching the Sheets

It was necessary to chalk line the bin for the spacing of the courses, as otherwise it would be easy to have allowed too much lap, and especially in view of the weight of the sheets and their insistence upon sliding down a trifle when securing, the result being that when the top and last course was laid, it would not reach to the top of the bin. Furthermore, the horizontal chalk lines were a help in keeping the pieces straight in position. While at first it seemed that there might be some confusion and difficulty in finding the proper pieces or keeping the pieces belonging to one bin from getting mixed up with those of another, the event proved that it was easy to keep the bins separate, and practically no time was lost in searching for the missing pieces.

Fig. 143 indicates how the sheets were punched. A rolling table, the upper surface of which was on a level with the lower die of the punch, was guided in tracks made by nailing strips of wood on the floor across the front of the punch. A long gauge was secured to the under jaw of the punch which guided the iron, so that the center of the holes would be ½ in. from the edge of the sheet. On this gauge were two marks *a* and *a'*, located 3 in. on each side of the punch. As accuracy to within ¼ in. in the spacing of the holes was not required, it was only necessary to lay the sheet on the table as indicated, and starting from one end punch a hole, then sliding the sheet along until the hole just punched came opposite to mark *a* or *a'*, according to whether the punching was being done from right or left, and punch a second hole, the second hole then being shifted opposite the mark and a third hole punched, etc. The punch was worked by a hand lever, and as the bench was easily moved along, a stout boy alone did all the punching. The pieces were marked on the edges to be punched, when being laid out.

GRAVEL ROOFER'S KETTLE AND FIRE PLACE

The thickness of the metal to be used depends upon the size of the kettle and fire place. Whatever thickness is used the construction can be similar to that shown in Fig. 144, in which A A shows the fire pot seamed to the bottom B B at C C. At the top of the fire pot an angle iron D D is riveted, as shown at *a a*. At E is the elbow, beaded and flanged as shown respectively by *b* and *c*, while F shows the damper in position.

The angle iron H H, riveted as shown, supports the grate J J, while K shows the opening for the ash pit door, around which grooves are riveted, into which the door will slide as shown by *e e*. The opening for the fire door is at L and around

it grooves are riveted as indicated at *f f*. The tar kettle M M is double seamed to the bottom at N N, on the top of which an angle, O O, is riveted as shown by *i i*. The pitched cover P is seamed to the collar, as shown by R R. The handle S is riveted at *m m*. The wheels and axle T U T are fastened to the bottom of the fire pot, as shown in Fig. 145, in which A is part of the fire pot and B the section of the axle, which is fastened to the bottom by means of the angle C C, riveting at *a a a a*. The balance legs are shown at D D, one being fastened on either side of the fire pot and riveted at E and E, which forms a pivot.

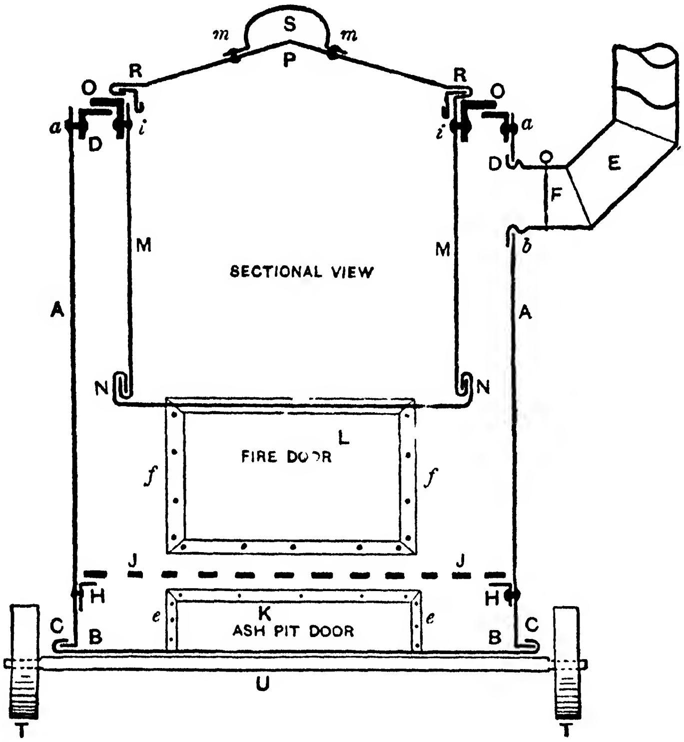


Fig. 144. Sectional View of Fire Place and Kettle

When the fire pot is to be wheeled to a certain place the legs D D are raised, and afterward lowered, thus preventing

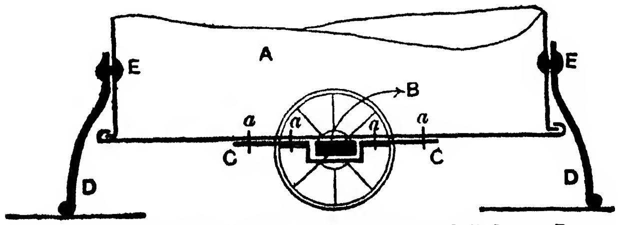


Fig. 145. Method of Fastening Axle and Balance Legs

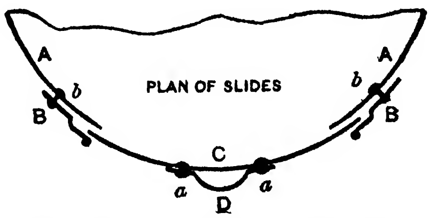


Fig. 146. Construction of the Slides

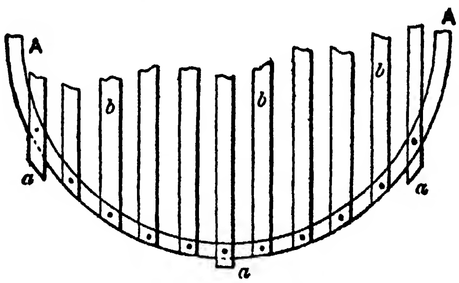


Fig. 147. The Grate Construction

the kettle from tipping. Fig. 146 shows how the slides and grooves for the doors L and K in Fig. 144 are constructed, while A A in Fig. 146 shows the part body

of the fire pot, cut out as shown from *b* to *b*. The riveted grooves are shown by B B, in which the door C slides, D being a handle riveted at *a a*.

Fig. 147 shows the construction of the grate, which can be made from band iron. The outside ring A A should be a trifle smaller than the inside diameter of the angle iron ring D D in Fig. 144, so that it can be removed when desired. Three of the grate bars, as *a a a* in Fig. 147, are to project over the ring as shown, these projections to rest on the angle iron H H in Fig. 144. The balance of the grate bars, as *b b b*, etc., in Fig. 147, are riveted. It will be noticed that the angle iron ring at the top of kettle in Fig. 144 rests upon the angle iron ring D D at the top of the fire pot. This allows the kettle to be removed for cleaning purposes. If desired, the fire pot and kettle can be made square, using the same construction, which, however, can be modified to suit.

POINTS ON WORKING HEAVY SHEET IRON

The following is a description of how a power punching machine was used in the working of heavy sheet iron. The method of making ice cans is used to illustrate how such work was handled, and it will be seen that the equivalent of many of the methods or operations can be applied to various other kinds of heavy work.

The cans were made of Nos. 16 and 18 galvanized iron, according to size, which was governed by the weight of the block of ice to be frozen, 100 lb., 200 lb., or 300 lb., these being the commonest sizes of blocks. For the benefit of those who may not be familiar with the manner in which the cans are used for making artificial ice, it is stated that the large vat of salt water containing the ammonia filled freezing pipes is floored over and openings left in the floor just the size of the can under the heavy wrought iron stiffening band. Fig. 148 is a view of a typical can. The cans are then filled with pure water and let down through the openings in the floor into the solution of salt water underneath, and covered. As the temperature of this solution can be and is reduced below 32 degrees, which is the freezing point, without congealing, whereas the pure water congeals at 32 degrees, the result is a solid block of ice in the can. The ice filled can is then raised, but by means of a traveling overhead tackle with hooks inserted in the holes in the sides and placed under a stream of warm water which melts the ice loose from the sides and bottom so the block will slip out. The can is made slightly tapering to facilitate this, and it must be perfectly smooth on the inside; no rivet heads, lumps of solder or buckles being allowed to project at all.

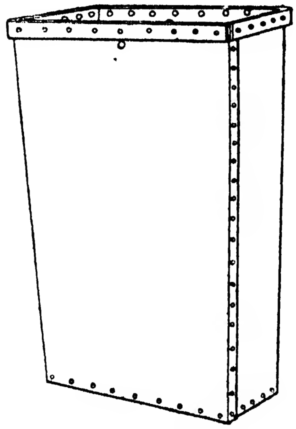


Fig. 148

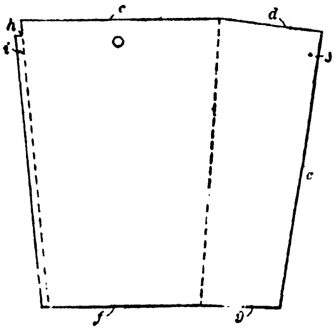
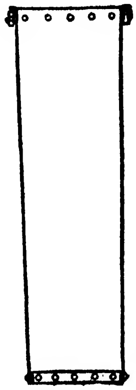


Fig. 149


Fig. 150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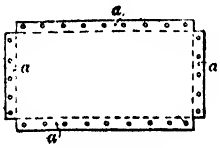


Fig. 152

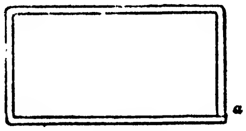
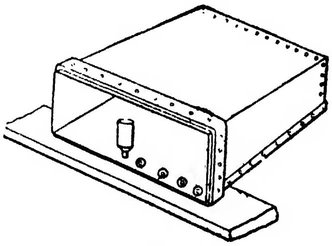


Fig. 154



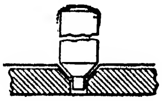


Fig. 156

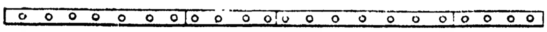


Fig. 153

Fig. 155


Fig. 157

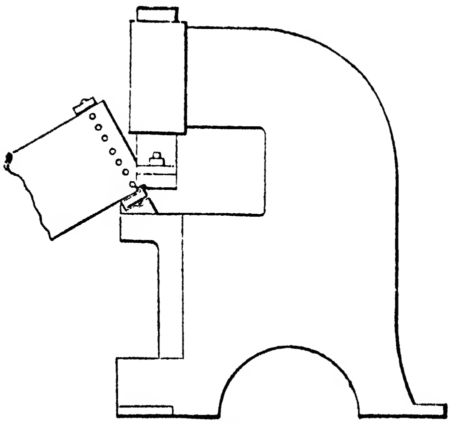


Fig. 158

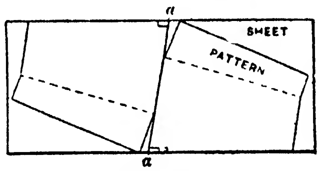


Fig. 159

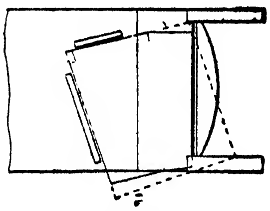


Fig. 161

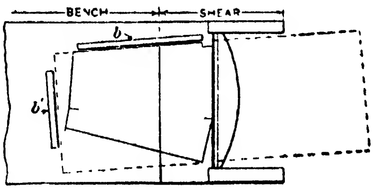


Fig. 160

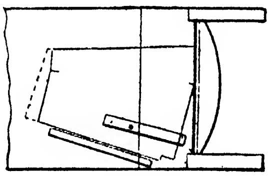


Fig. 162

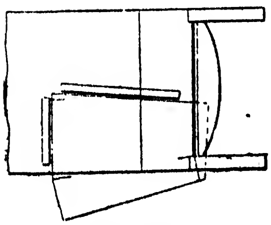


Fig. 163

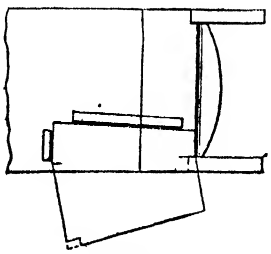


Fig. 164

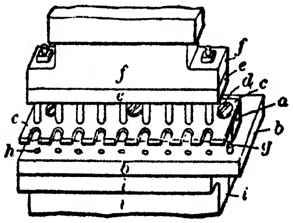


Fig. 165

Various Details in the Making of Ice Cans

One size of can was about 11 × 22 in. at the top and 10½ × 21½ in. at the bottom and 44 in. high. Fig. 148 is a view of a completed can, which it will be seen is made in two pieces, with seams at diagonally opposite corners. Fig. 149 is a half pattern, Fig. 150 a horizontal section, Fig. 151 a vertical section and Fig. 152 a pattern of the bottom. The 1-in. edges, *a*, of the bottom, after being punched for riveting, are turned down square, and then slipped into the bottom of the can and riveted as indicated at Fig. 151.

The stiffening band was made of 1¼ × ⅜-in. iron, laid out, punched, and countersunk, as indicated in Fig. 153. It was then formed up, as indicated in Fig. 154, with the countersunk ends of the holes on the inside of the band and joint *a* welded. After the cans were formed and riveted together the stiffening bands were slipped over the top, allowing the sheet metal to project about 5-16 in. above the band. The can was then laid on a mandrel, as indicated in Fig. 155, and holes punched through the sheet metal by hand for riveting on the bands. Fig. 156 is a sectional view showing the form of punch used, which first punched a hole a trifle smaller than the rivets to be used, and by added blows of the hammer drove the sheet metal down into the countersink of the rivet holes in the band, so that the countersunk head rivets used would be laid in flush with the inside of the can, as shown in Fig. 157. Then the edge which was left projecting above the band was laid over square on top of the band by a special die in the punching machine, as indicated in Fig. 158.

The material was ordered of such a size that one complete can could be cut out of a sheet, as indicated at Fig. 159, and the cutting was done with a 36-in. gap shear by means of gauges, so that while the pattern was used to set the gauges by, no marking was done on the sheets. The first operation was the cutting of the sheet in half on the oblique line *a a*, Fig. 159. This was governed by gauges, *b* and *b'*, Fig. 160, which were temporarily but securely tacked to the bench that sat in front of the square shear and was permanently connected thereto. It will be seen that this cut not only severed the sheet, but made the cut *c* of pattern, Fig. 149, on both halves of the can. The solid lines show how the pattern was laid on the bench and against the blade of the square shear for setting the gauges, and the dotted lines represent the sheet.

Fig. 161 indicates how the gauges were set for making cut *e*. As the side of the can was about 44 in. long, while the square shear was 36 in., it was necessary after cutting the length of the blade on side *e*, to raise the material above the gauges, and push it along for the second bite of the shear, which finished cut *e*. Fig. 162 indicates how cut *d* was made; Fig. 163 shows the arrangement for cutting *f*; Fig.

164 shows how *g* was cut. This completed a half side with the exception of notch *h*, Fig. 149, which was cut with a special notcher in the punch machine. Notch *h* was made the depth of the stiffening band plus the 5-16 in. edge, which was turned over. Similar cuts of all similar pieces were made at one time. For instance, if 500 cans were being made, 1000 cuts would be made at each set of the gauges.

The sheets were punched for riveting by a gang punch die arrangement in the punching machine; Fig. 165 is a front view of this, and Fig. 166 a longitudinal sectional view on center line of punches. The rivet laps on the bottom and sides of the cans were 1 in. wide and the center of the rivet holes was $\frac{1}{2}$ in. from the edge. In Figs. 165 and 166, *a* is a gauge set $\frac{1}{2}$ in. back from the center of the holes in the lower die *b*. The letter *c* is the stripper, made of $\frac{1}{8}$-in. thick sheet iron and secured by screws *d*, which also secure gauge *a* to die plate *b*. It will be seen that the punches were provided with countersunk heads and were laid into the upper die plate *e*, which was attached to the plunger *f*.

The punching of the holes in the bottom of the can and in the bottom ends *f* and *g* of the body of the can was comparatively simple, but great accuracy was required in punching the holes for the side seams, as the slightest longitudinal discrepancy resulted in a twisted can, and it requires much longer to melt the ice out of a twisted can than one which is true. Breweries and factories usually reject twisted cans. In order to avoid twisting, the two first holes, *i* and *j*, Fig. 149, were accurately located, and made in the pattern, and after the sides were cut the pattern was carefully laid on same, so that the edges would match perfectly, and clamped in position, and the holes *i* and *j* machine punched through the holes in the pattern; the pattern being reinforced around holes, *i* and *j*, by a $\frac{1}{8}$-in. thickness of band iron.

When side *e* was being punched, hole *j* was slipped over the projecting punch gauge *g*, Figs. 165 and 166, the center of this punch gauge being located just one rivet spacing from the first hole in die *b* (the rivets were spaced about $1\frac{1}{4}$ in. apart). The plunger was then brought down punching 9 or 10 holes, as indicated, then the sheet was pulled along, and the last hole punched at *h*, Fig. 165, was slipped over the guide punch *g* and the operation repeated until the entire side was punched. This process was repeated on the other side, starting with hole *i*. The bottom edges *f* and *g* of the body, Fig. 149, and the bottom piece, Fig. 152, were punched in a similar manner, so that when the can was formed ready for riveting, all holes matched perfectly. Countersunk head rivets were used.

The side seams of the cans were riveted by hand on a long mandrel. The rivets were inserted in the manner indicated in Fig. 167, it being necessary to slip

the last rivet inserted onto the mandrel before putting in the next one, thus the mandrel held the rivets in as fast as they were inserted, and the cans gradually slipped onto the mandrel.

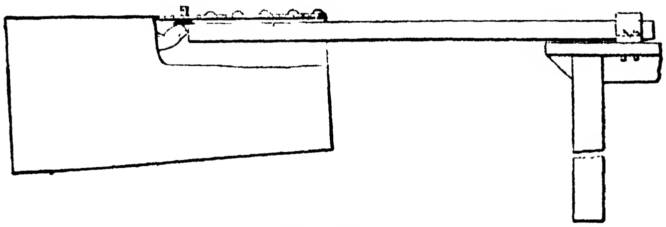


Fig. 167

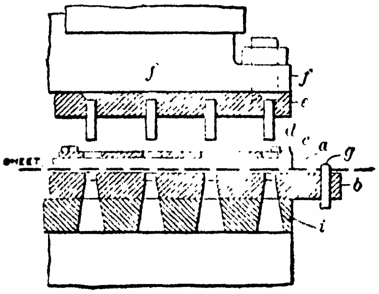


Fig. 166

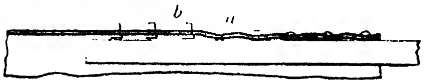


Fig. 168

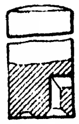


Fig. 169

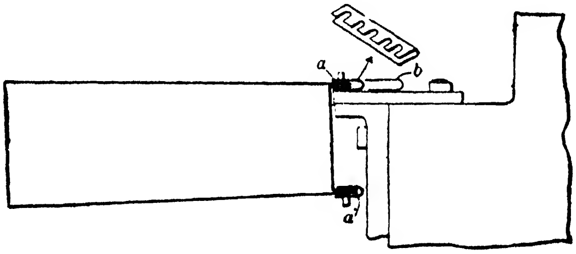


Fig. 172

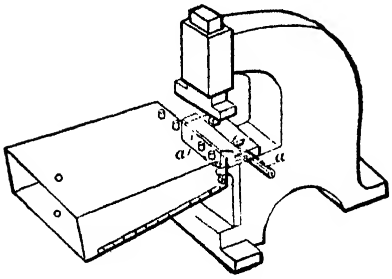


Fig. 170

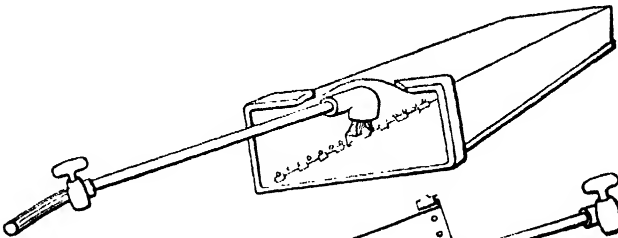


Fig. 173

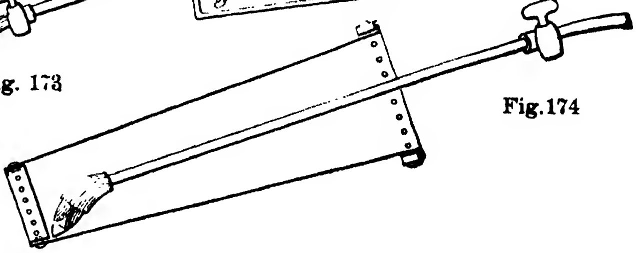


Fig.174

Fig. 171

Method of Riveting and Soldering Ice Cans

It was found that if all the rivets were put in before being drawn and headed up, the seam would be wavy on the inside, because when a rivet was set down as at *a*, Fig. 168, the next rivet *b*, not having been drawn, held the material up, which resulted in a kink and stretched the material so that it was difficult to get it

to lie smooth. It was, therefore, found best to draw and head up each rivet as it was put in; one operator doing the riveting, while the other was inserting and assisting in holding the can in position.

Fig. 169 is a sectional view showing the bottom of the rivet sets used. The bottom of the cans was riveted in on the punching machine, as indicated in Fig. 170. Fig. 171 shows the gang set and header used under the plunger, as indicated by *a*, Fig. 170. The rivets were inserted in the bottom by hand and secured by clips, *a* and *a'*, Fig. 172. Then the can was laid in position on the mandrel of the punch, as shown in Fig. 172, and clips, *a*, pushed out of the way, as indicated by lines, *b*. Clips *a* were made the same length as the gang-set. All the rivets around the bottom were inserted and held in position by the clips before the can was put into the machine for riveting. The stiffening bands were gang-riveted on the top of the cans in the machine, in a similar manner, after which the edges were turned over, as indicated in Fig. 158.

The solder for the side and bottom seams was cut up into small pieces, and after the acid was applied these bits of solder were laid on the seam at intervals, as indicated in Fig. 173. A heavy hatchet forged gas heated soldering copper, as indicated in Fig. 173, was used for soldering the side seams on the inside of the can, and a similarly heated bent chisel forged copper was used for soldering the bottom seams on the inside of the can, as indicated in Fig. 174.

PATTERNS FOR IRREGULAR PIECED ELBOWS

This problem is how to obtain the true angle of the center elbow, B, shown in Fig. 175; for a rule for the center elbow where A, B and C are any given angles, and for the twist required for the elbows B and C to bring them in the proper position to punch holes for rivets before putting together. A B C shows the elevation of the elbows, and A^1 B^1 C^1 is the plan. Fig. 176 is a perspective view of Fig. 175.

In Fig. 177, draw the plan and elevation of the center line of the elbow, as shown. In this elevation A^2 A^1, B^1 C^1 and C^1 C^2 are the full size of the lines they represent, so A^1 B^1 is the only line the true length of which must be found. The true angle at C^1 is shown, so it will be only necessary to determine the true angles at A^1 and B^1. From A^1 draw the horizontal line A^1 D, intersecting C^2 C^1, extended at D. From B^1 drop a line intersecting A^1 D at E. Equal to and parallel to A B in plan draw A^3 B^2, at right angles to which lay off B^2 B^3 equal

to E B^1 in elevation. Draw A^3 B^3, which is the true length of A B, or A^1 B^1. At right angles to B^2 A^3 draw A^3 A^4, equal to A^1 A^2; then will B^3 A^3 A^4 be the true angle of the elbow A^2 A^1 B^1 in elevation. On either side of the center line B^3 A^3 A^4 draw the pipe and the miter line 1′ 5′, as shown.

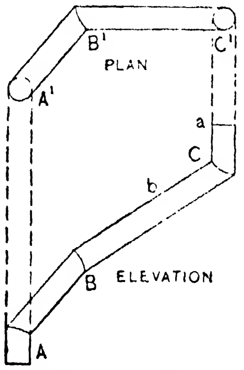


Fig. 175. A Sketch of the Problem

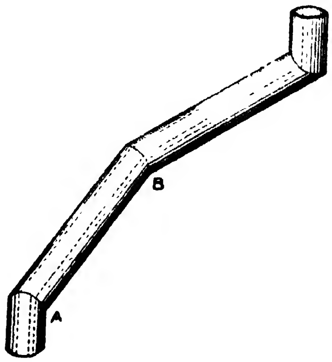


Fig. 176. Perspective View of Elbow

To obtain the true angle at B^1 in elevation proceed as is shown in Fig. 178. Draw any horizontal line, as A C, equal in length to a line drawn from A to C in Fig. 177. Take the vertical hight from the points A^1 to C^1 in elevation, as D C^1, and place it in Fig. 178 on a line drawn from C at right angles to C A, as C C^1. Draw C^1 A, the true length between A and C in plan in Fig. 177. The true angle is obtained by using as radius A^3 B^3 in Fig. 177, and with A in Fig. 178 as center, describing the arc B. Then, with a radius equal to B^1 C^1 in Fig. 177, and with C^1 in Fig. 178 as a center, describe an arc intersecting the arc previously drawn at B. Draw a line from A to B to C^1. Then will A B C^1 be the true angle of the elbow shown by A^1 B^1 C^1 in elevation in Fig. 177.

The next step is to construct a developed elevation in which the true miter lines are obtained, as shown in Fig. 179. Take a tracing of A^4 A^3 B^3 in the oblique elevation in Fig. 177, and place it as shown by A A^1 B in Fig. 179; then take a tracing of the true angle A B C^1 in Fig. 178 and place it in Fig. 179, placing the line A B of Fig. 178 over the line A^1 B in Fig. 179, and obtain A^1 B C. As B^1 C^1 C^2 in elevation in Fig. 177 is the true center line and angle of that elbow, take a tracing of same, placing the line B^1 C^1 over the line B C in Fig. 179, and obtain B C C^1. Then will A A^1 B C C^1 be the developed center line with the true angles of the full elbow. On either side of the center line in Fig. 179 lay off the half diameters and draw side and miter lines.

In its proper position draw the profile of the pipe A^2. Assuming that the seam is to come at the point 1 in the plan A in Fig. 177, divide A^2 in Fig. 179

into an equal number of parts, and start to number same on the shortest side of the first piece of pipe, A A^1, as shown in plan at 1, which corresponds to point 1 in the plan A in Fig. 177. From the various intersections, 1 to 8 in plan, erect lines into the elevation, cutting the miter line 1′ 5′, as shown; from which,. parallel to A^1 B, draw lines intersecting the miter line 1″ 5″, as shown. Continue these lines parallel to the center lines in the other pieces of the elbow in the usual way.

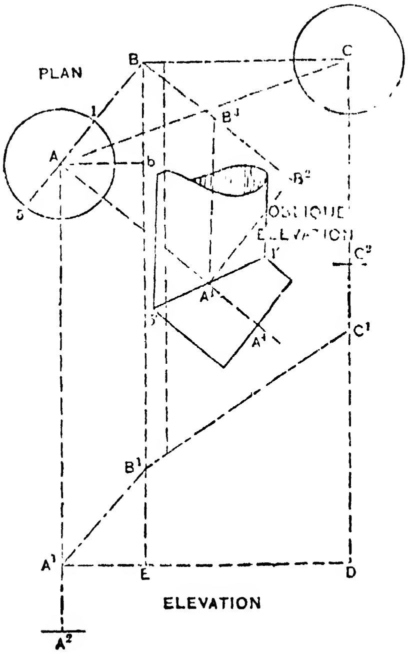


Fig. 177. Plan and Elevations

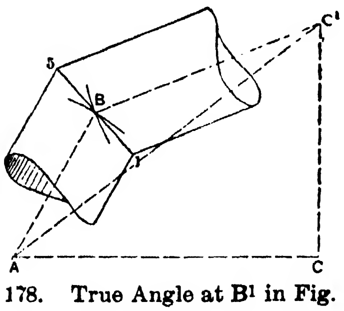


Fig. 178. True Angle at B^1 in Fig. 177

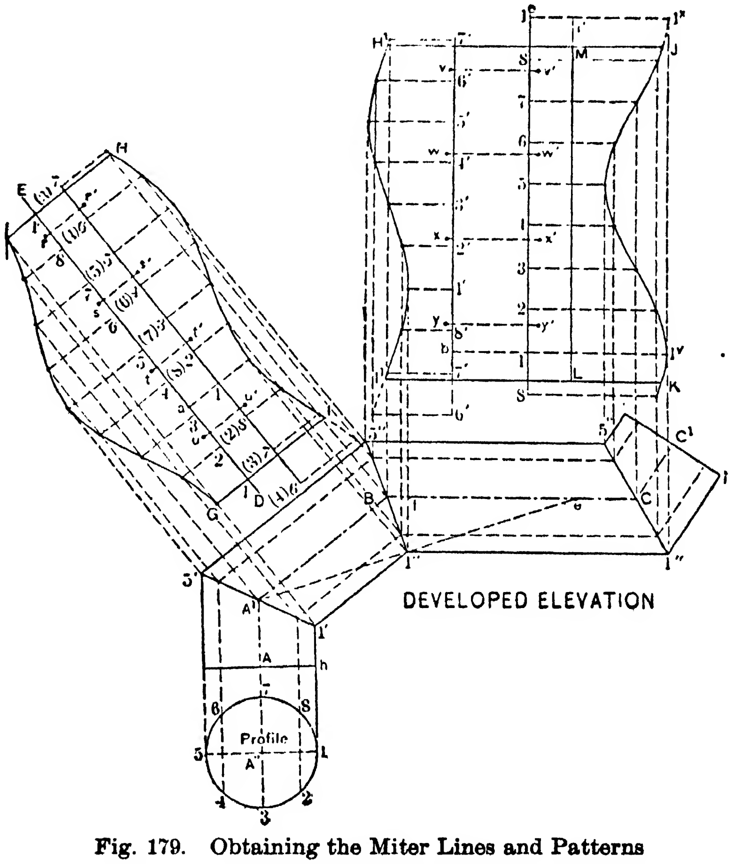


Fig. 179. Obtaining the Miter Lines and Patterns

It is now necessary to know how much the elbow B will turn on the elbow A^1, and how much the elbow C will turn upon the elbow B. To accomplish this another operation in projection is necessary, and is shown in Fig. 180, in which the center line A° A^x B C C^1 is a reproduction of A^3 A^1 B^1 C^1 C^2 in Fig. 177. Take a tracing of the plan A with the intersections 1 and 5 on same and place it directly under A^x A° in Fig. 180, as shown, the point 1 representing the shortest

side of the lower arm of the elbow. Take a tracing of A^4 $1'$ A^3 $5'$ in Fig. 177, which is similar to A $1'$ A^1 $5'$ in Fig. 179, and place it as shown by A^4 $1'$ A^3 $5'$ in Fig. 180, being careful to have the points A^4 and A^3 meet the horizontal lines drawn from the points A° and A^x, respectively. Directly below A^4 draw the plan A^1, which divide into the same number of spaces as the plan A, being careful to have 1 come directly below $1'$.

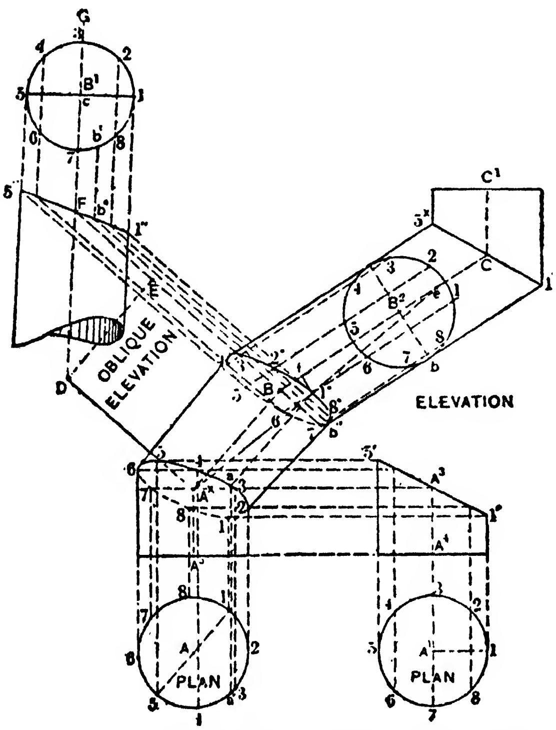


Fig. 180. Obtaining the Twist in Each Angle

From the various intersections in A^1 in Fig. 180 erect lines intersecting the miter line $1'$ $5'$, from which intersections, at right angles to A^3 A^4, draw lines, which intersect with lines drawn parallel to A^x A° from similar numbered intersections in A, resulting in the intersections 1 to 8 in A^x. Through these points trace the ellipse shown, which is the miter line in elevation. With the use of this miter line the amount can be obtained that the elbow B in Fig. 179 will turn upon the elbow A^1, there being in this problem a continuous seam. From the center line A^1 on the first miter line $5'$ $1'$ draw a line through the lowest point of the second miter line at $1''$, which represents the line of the seam, and extend it until it intersects the center line B C at *e*. At right angles to B C, from $1''$, draw the line $1''$ *f*, intersecting B C at *f*. Now take the distances from B to *f* and *f* to *e* and place them on similar center line in Fig. 180, as shown. It must be remembered that Fig. 180 is a projection, and while B C in Fig. 180, in this case, shows the true length of B C in Fig. 179, it will not do so in most instances. If it does not, it is necessary to lay off the true distances B *f* and B *e* on the true length of B C, and then project the points properly on B C in Fig. 180. Draw a line from *e* to point A^x, which represents the similar point A^1 in Fig. 179. Then in Fig. 180, from *f*, at right angles to the line, not the projection of, B C, draw *f* 1°, which will intersect A^x *e* at 1°, the same relative position in elevation as $1''$ in Fig. 179. From the point 1° in Fig. 180 parallel to the center line B A^x, draw a line intersecting the miter line shown by the ellipse at *a* between 3 and 4. From *a* drop a line into the plan intersecting the circle *a'*. The point *a'* indicates the amount that the second elbow will be turned upon the lower one—that is, from 1 to *a'*.

The next step is to find how much the upper elbow will be twisted upon the middle elbow. From 1° in elevation parallel to the center line B C draw 1° 1. Now, with any point on the line B C, as B^2, as center, and radius equal to A 1 in plan, describe the circle B^2, intersecting 1° 1 at 1. Then will this point 1 represent *a′* in plan and be numbered 1 in the profile B^2. Divide B^2 into eight equal parts. An operation in projection is now required to find the miter line of the middle elbow. Parallel and equal to A^x B draw the line D E, as shown. At right angles to D E erect E F, equal in distance to *b* B in plan in Fig. 177. Draw a line from F to D in Fig. 180, which equals A^3 B^3 in Fig. 177, or A^1 B in Fig. 179. Now take a tracing of 5′ 5″ E 1″ 1′ A^1 and place it in Fig. 180, placing the center line A^1 B upon the center line D F, and obtain the miter line 5″ 1″. Draw the profile B^1. Through *c* draw a horizontal line, as 1 5, and divide the circle also into eight equal parts, starting to number at the shortest side of the pipe. From the various intersections in B^1 in Fig. 180 draw lines parallel to G D, intersecting 1″ 5″. From these intersections, at right angles to A^x B, draw lines, which intersect with lines drawn parallel to B C in elevation from similar numbers in the profile B^2, resulting in the intersections 1° to 8°. Trace an ellipse through these points.

It will be noticed that a line drawn from 1″ in the oblique elevation meets the point 1° in elevation previously obtained on the line A^x *e* from *f*. As the upper angle of the elbow is the true angle similar to the upper angle in Fig. 179, then will the seam line or point 1‴ be represented in Fig. 180 by 1^x, and 1^x 5^x will be the true miter line, and no operation in projection will be necessary. If, however, this elbow was drawn so as not to show the true angle, then to find how much the upper elbow in Fig. 180 would turn upon the center one would require an operation similar to that used in connection with the turning of the center elbow on the lower one. Then the point *b* will represent the seam line of the elbow, 1‴ in Fig. 179, and the upper elbow will be turned upon the center one a distance equal to 1 *b* in the profile B^1 or B^2 in Fig. 180.

The final step is to develop the patterns, as shown in Fig. 179. At right angles to A^1 B draw the line D E, upon which place the stretchout of the plan A^2, as shown by similar figures on E D. At right angles to E D and through the small figures draw a line, which intersect with lines drawn at right angles to A^1 B from similar numbered intersections on the miter line 1′ 5′. Through points thus obtained trace a line, as shown by F G, which is the miter cut for the lower elbow. Now take the distance from 3 to *a′* in the plan A in Fig. 180 and place it in Fig. 179 on the line E D, between the points 3 and 4, as shown from 3 to *a*. Parallel to E D draw any line, as 6 7, at right angles to which from *a* draw a line intersect-

ing the line 6 7 at 1. Then starting from 1 lay off similar stretchout as on E D, as shown from 1 to 7 and 1 to 6, allowing the spaces to project over the lines 1 and 1′ on E D. At right angles to 7 6, from the various intersections on same, draw lines, which intersect by lines drawn at right angles to A^1 B from similar numbered intersections on the miter line 1″ 5″. A line traced through points thus obtained, as shown by H I, will be the miter cut for the middle elbow. Extend the lines F 1′ and G 1 in the pattern, as shown, respectively, by F H and G I, intersecting the miter cut H I at H and I, respectively. Then will F G I H be the pattern for the piece A^1 B in elevation, with the upper miter cut H I in its proper position to give the middle elbow the required twist over the lower one.

If the piece A^1 B requires a joint in the middle and holes are to be punched before rolling, then mark off the holes, as many as required, as shown by *r*, *s*, *t* and *u*, and parallel to the lines of the pipes carry them across on the upper cut H I, as shown by *r′*, *s′*, *t′* and *u′*. Then when the pieces are rolled up and fitted hole over hole the elbows will be twisted in their proper position.

For the pattern for the lower arm of the first elbow take the distance *h* 1′ and place it in the pattern, as shown by G 1 and F 1′, and draw a line from 1 to 1′. Then will 1′ F G 1 be the pattern for A A^1 with the seam on the shortest side. H^1 7′ 7′ I^1 is a reproduction of H 7 7 I in the pattern for the second piece. For the opposite cut of the third piece proceed by a method similar to that by which the second piece was determined. The method of punching in this piece is shown by *v w x y* and *v′ w′ x′ y′*. For the pattern for the upper arm, C C^1, proceed as in the pattern for the first piece. In the patterns shown the seam will run along the bottom from *h* to *i* in a continuous line. Laps must be allowed.

PATTERNS FOR A FORGE HOOD

To obtain the patterns of a hood for a forge similar to that shown in Fig. 181, the hood is bolted to the forge at A and seamed at B and C. Proceed as follows:

The methods for obtaining the patterns are shown in Fig. 182, in which A B C D E F is the elevation of the hood, G being the plan view on E H, and M and N the plan views of F C and A B, respectively.

The lower part of the hood, shown by F C D E, will be developed first. Divide one half of the profile G into equal spaces, as shown from 1 to 7, and from the points 1 to 4, or as much as is taken up by the curve C D in elevation, erect vertical lines cutting the curve as shown from C to D. Establish an extra point *a′*,

from which drop a vertical line intersecting the profile G at *a*. Extend the line E D as H J, and then, on it place the full girth of the profile G, as shown by similar figures on H J. At right angles to H J erect vertical lines, which intersect by lines drawn parallel to H J from corresponding intersections on the curve C D in elevation. A line traced through points thus obtained, as shown by L K 4 4, will be the desired pattern, to which edges must be allowed for seaming and riveting.

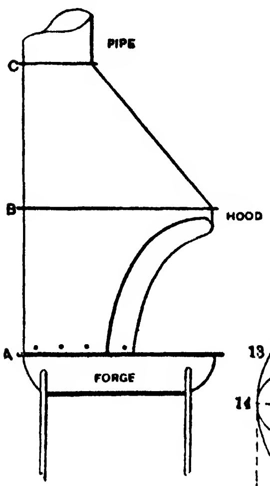


Fig. 181. View of Forge Hood

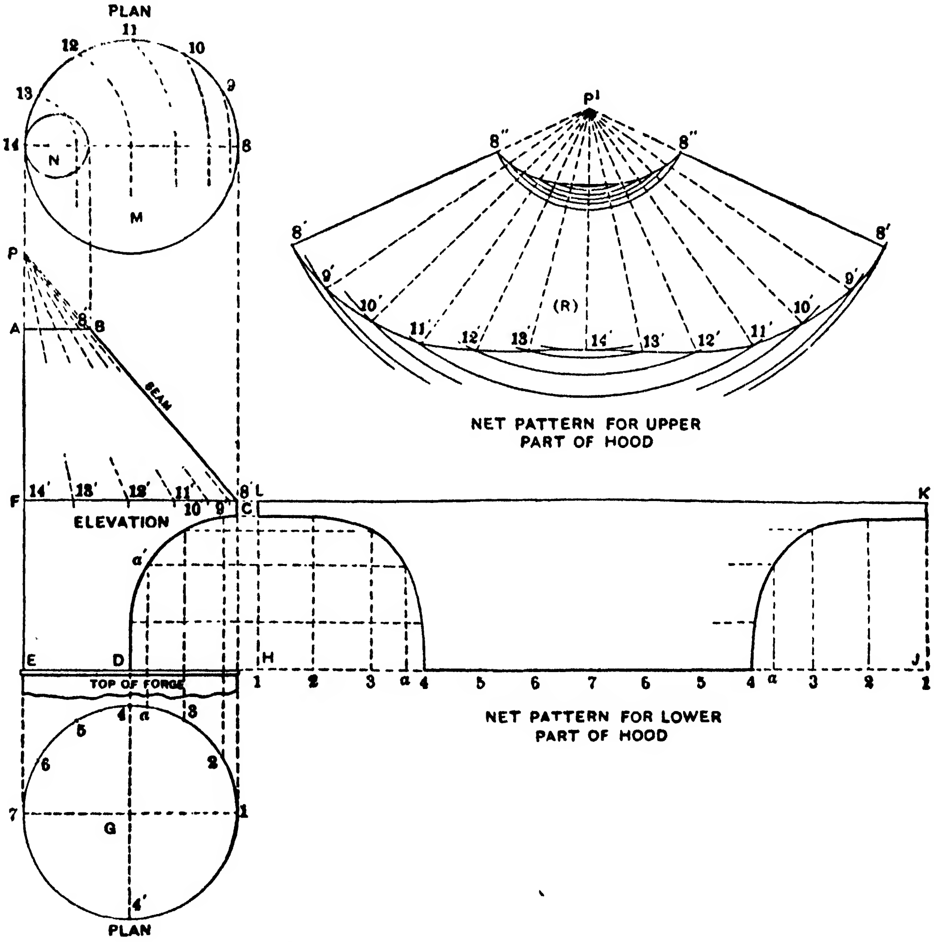


Fig. 182. Plan, Elevation and Patterns

The pattern for the upper part of the hood A B C F is obtained as follows: Extend F A and C B until they intersect at P. P is then the apex of a scalene cone, the apex shown in plan by 14. Divide the semicircle M into equal spaces, as shown from 8 to 14, and with 14 as center and radii equal to 14 13, 14 12, 14 11, 14 10 and 14 9, draw arcs intersecting the center line 8 14 as shown, from which points lines are carried vertically to the elevation, cutting the base of

the cone F C at 8′, 9′, 10′ to 14′. From the various points 8′ to 14′ draw radial lines to P, cutting the line A B as shown.

These various radial lines give the true lengths or radii to develop the pattern shown by (R). Therefore, with P^1 as center and radii equal to P 14′ to P 8′ draw arcs in (R) as shown by similar numbers. Now set the dividers equal to one of the equal spaces in plan M, and starting from arc 14′ in (R) step to arc 13′, then to 12′ and so on until the arc 8′ has been intersected on both sides. From these points draw radial lines to P^1, which intersect by arcs having radii of similar numbers, obtained from P in the elevation, to various intersections on A B. For example, using P 8″ as radius, and P^1 in (R) as center, intersect the radial lines 8′ P^1 on both sides at 8″ 8″. Through points thus obtained trace the pattern shown by 8′ 8″, 8″ 8′, to which edges are allowed for seaming and riveting.

PATTERN FOR SHEET IRON FORGE HOOD

In Fig. 183 is shown a perspective view of a forge hood in which A is the forge hood, connected to the round smoke pipe at C and bolted to the forge at B. In developing this style hood, a lot of time and drawing can be saved by following the short, accurate rule given in the following two figures:

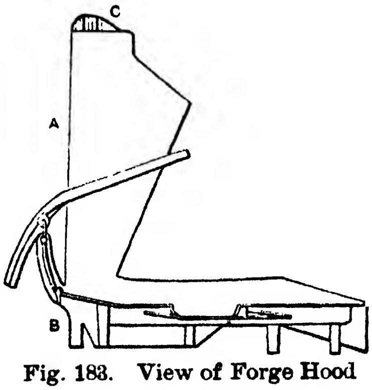


Fig. 183. View of Forge Hood

Let A B C D E in Fig. 184 be the side elevation of the forge hood, the plan of which on A B, is shown by F and the partial section on E D is shown by G H. Bisect both plans as shown by the dotted lines *a b* and *c d*. The pattern will be developed without the use of a plan, for if a plan was used it would be necessary to project a horizontal section into the plan from the line C D in elevation, which is to be avoided when both halves of the article are symmetrical.

The short rule is shown in Fig. 185, in which 1, 5, 6, 9″ 13 is a reproduction of A B C D E in Fig. 184. Take a tracing of the half plan *a b* F and *c d* G and place it in Fig. 185 as shown by *a* and *c*, respectively.

Obtain a true section on the line 6 9″, as follows: Draw the perpendicular 9″ 9 equal to 9″ 9′, and at pleasure draw any desired sweep or shape as shown by 6 8 9. It should be understood that this shape can be made at will, so long as the distance 9″ 9 is equal to 9″ 9′. Divide the curves in the semisections *b* and *c*

into equal spaces (two in each) and divide the semisection *a* into as many spaces as contained in *b* and *c* (in this case four). Number these points 1 to 5 in *a*, 6 to 9 in *b* and 9′ to 13 in *c*. At right angles to 1 5, 6 9″ and 9″ 13 and from the various divisions in the semisections *a*, *b* and *c* draw lines intersecting respectively the lines 1 5, 6 9″ and 9″ 13, as shown by similar numbers. Connect the various points by dotted and solid lines, as shown.

The next step is to obtain the true lengths of the solid and dotted lines shown in A, as shown respectively in diagrams B and C. In A, 1 13 and 5 6 show their true lengths. To obtain the true length of 2′ 11′ in A, take that distance and place

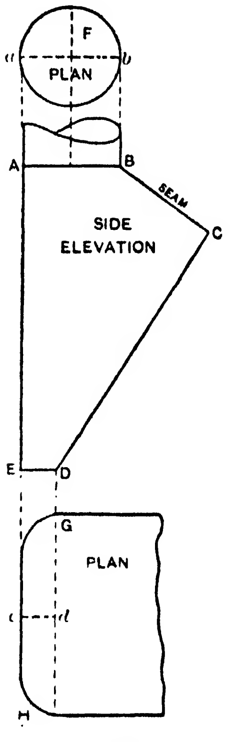


Fig. 184
Detail of Forge Hood

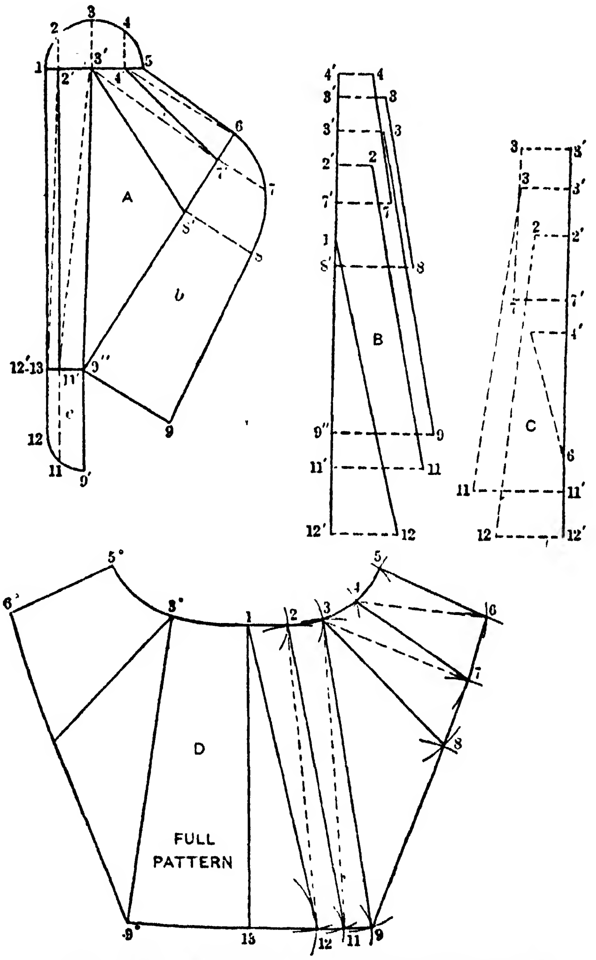


Fig. 185. Developing Pattern for Forge Hood

it as shown by 2′ 11′ in B. Erect the perpendiculars 2′ 2 and 11′ 11, equal respectively to similar numbers in the semisections *a* and *c* in A. Then 2 11 in B is the true length of that numbered line in A. In this manner all of the true lengths of the solid lines are obtained in B and that of the dotted lines in C, as shown by similar numbers.

For the pattern in which the seam is to come on 5 6 in A, proceed as shown in D. Draw the vertical line 1 13 equal to 1 13 in A. With 13 12 in *c* as radius and 13 in D as center draw the arc 12, which intersect by an arc struck from 1 as center and 1 12 in B as radius. Now with radius equal to 1 2 in *a* and 1 in D as center draw the arc 2, which intersect by an arc struck from 12 as center and 12 2 in C as radius. With radius equal to 12 11 in *c* and 12 in D as center, draw the arc 11, which intersect by an arc struck from 2 as center and 2 11 in B as radius. Proceed in this manner, using alternately the divisions in *a*, the true lengths in C, the divisions in *c* and the true lengths in B until the line 3 9 in D is obtained. With radius equal to 9 8 in *b* and 9 in D as center, draw the arc 8, which intersect by an arc struck from 3 as center and 3 8 in B as radius. Proceed as before, using alternately first the divisions in *b*, the true lengths in C, the divisions in *a* and the true lengths in B, until the line 5 6 in D is obtained, being measured from 5 6 in A. Then 1 5 6 9 13 in D is the half pattern, and when traced opposite 1 13, as shown by 3° 5° 6° 9°, will complete the full pattern, to which edges must be allowed for seaming and riveting.

PATTERN FOR THREE-WAY BRANCH

The branch for which the pattern is to be developed is shown in Fig. 186, where A is the inlet, and B, C and D the three outlets or branches. In Fig. 187 is shown the plan and elevation of the three-way branch, the lines of the joints being indicated by I J and J K. The opening on the line A B is shown by L M N O, on C D by P R S T, and on E F by U V W X. The section on H G is represented by Y Z Y^1 Z^1, while A^1 B^1 C^1 D^1 E^1 F^1 are plan views of the three openings.

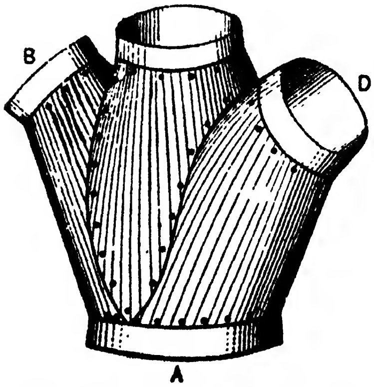


Fig. 186. The Finished Branch

Draw the line in plan from H^1 to Z to J^1, and from K^1 to Z^1 to L^1, which will represent the plan view on each side, taken on the dotted lines N^1 J W^1 in elevation. Knowing the hight and the width at the bottom, the shape can be established at pleasure, as in Fig. 188, where I J equals I J of the elevation, Fig. 187.

At right angles to I J in Fig. 188 draw the line Z Z^1 through J, making J Z^1 and J Z equal to J G or J H in elevation, Fig. 187, or equal to & Z or & Z^1 in plan. Through the points Z I Z^1 in Fig. 188 draw any desired elliptical figure, as shown, which will represent a true section on I J or J K in elevation, Fig. 187.

Only one pattern will be required, also a separate pattern for the center branch, both of which will be developed by triangulation.

To obtain the measurements for the sections for the center branch proceed as shown in Fig. 189, where 14 4 5 9 5′ 4′ is a reproduction of O^1 C I J K D in elevation, Fig. 187. As the four quarters of this center branch are alike, only one quarter pattern will be developed; then, if desired, the quarter patterns can be joined together, forming one pattern. Take a tracing of the quarter profile T Q P and place it as shown by 4 14 1 in Fig. 189. In similar manner take a tracing of the section I J Z^1 in Fig. 188 and place it as shown by 5 9 8 in Fig. 189. Divide the profile 1 4 into equal spaces, and in similar manner divide the profile 5 8 into the same number of spaces. In practice more spaces should be employed than are here shown, for the closer the divisions are made the more accurate will be the pattern.

At right angles to 4 4′ and 5 9 and from intersections on the curve 1 4 and 5 8 draw lines as shown, intersecting the lines 4 4′ and 5 9 at 12 and 13, and 10 and 11 respectively. Draw solid lines from 12 to 11, 13 to 10, 14 to 9, and dotted lines from 12 to 5, 13 to 11 and 14 to 10. Then will these solid and dotted lines represent the bases of sections which will be constructed, and the altitudes of which will be equal to the hights shown in the profiles. Thus in Fig. 190 draw the line 9 14, equal to 9 14 in Fig. 189; at right angles to 9 14 in Fig. 190 draw the lines 9 8 and 14 1′, equal to 9 8 and 14 1 in Fig. 189. Draw a line from 8 to 1 in Fig. 190, which represents the actual distance on the finished article on similar line in Fig. 189. Proceed in precisely the same manner for the balance of the sections.

For the sections on dotted lines in Fig. 189 proceed in the same manner as described in Fig. 190. For example, take the distance 10 14 in Fig. 189 and place it as shown by 10 14 in Fig. 191. At right angles to 10 14 from points 10 14 draw the lines 10 7 and 14 1, equal to 10 7 and 14 1 in Fig. 189. Draw a line from 7 to 1 in Fig. 191, which will represent the actual distance on the finished article on similar line in Fig. 189. Having now the necessary measurements in Figs. 189, 190 and 191, the pattern is obtained in Fig. 192 as follows:

Draw any vertical line, as 1 8 in Fig. 192 equal to 1 8 in Fig. 190. With 8 7 in Fig. 189 as radius and 8 in Fig. 192 as center describe the arc 7. Then, with 1 7 in Fig. 191 as radius and 1 in Fig. 192 as center describe an arc intersecting

the arc 7. Again using 1 as center and 1 2 in Fig. 189 as radius describe the arc 2 in Fig. 192. Then, using 2 7 as radius in Fig. 190, and 7 as center in Fig. 192, describe an arc intersecting the arc 2. Proceed in this manner, using, alternately, first the divisions in the profile 5 8 of Fig. 189, then the length of the slant lines in Fig. 191, the divisions in the profile 1 4 of Fig. 189, then the length of the slant lines in Fig. 190, until all the points in the pattern in Fig. 192 have been obtained. Trace a line, as shown by 1 4 5 8, which will be one quarter of the pattern.

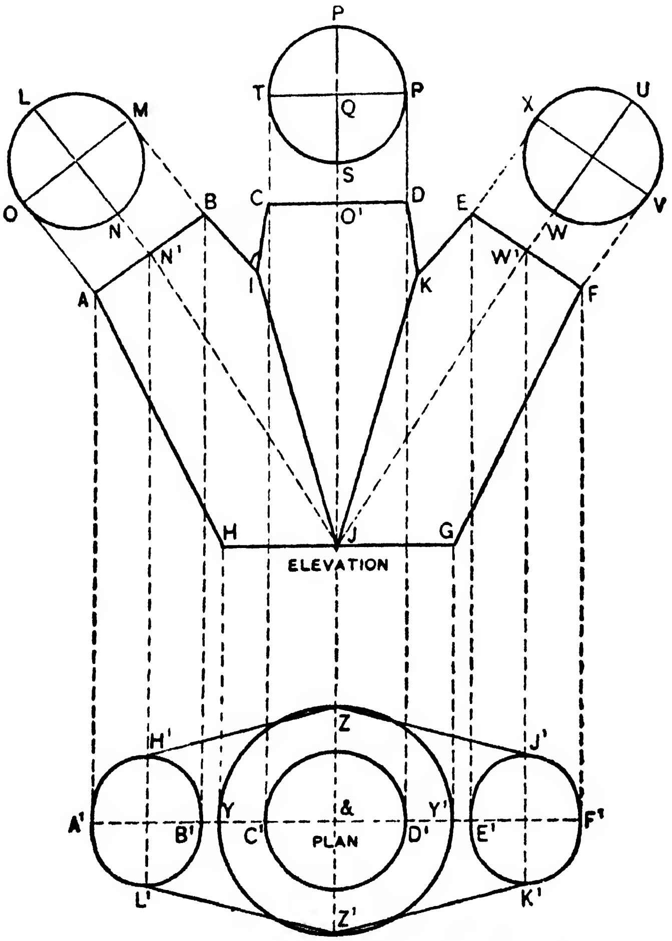


Fig. 187. Plan and Elevation of the Branch

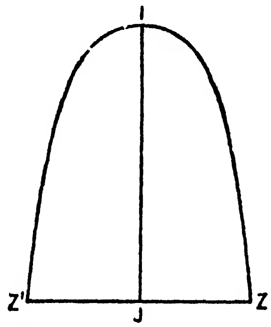


Fig. 188. Arbitrary Section of Branch on I J of Fig. 187

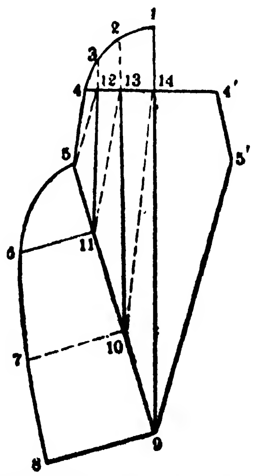


Fig. 189. Obtaining the Base Lines for Diagrams of Triangles

If the pattern is desired in one piece, then trace opposite the lines 1 8, 4′ 5, and 1′ 8′. Then will 4 4″ 5″ 8′ 8 5 4 be the full pattern for the center branch.

As the two side branches are alike one pattern will answer for the two. In Fig. 193 let 1 7 8 12 16 be a reproduction of E F G J K in elevation, Fig. 187. Take a tracing, shown by X U V in elevation, Fig. 187, and place it as shown by 7 4 1 of Fig. 193. In similar manner take a tracing of I J Z′ in Fig. 188 and

Y^1 Z^1 & in plan in Fig. 187 and place them as shown by 8 12 11 and 16 13 12 respectively in Fig. 193. Divide the two lower profiles 8 11 and 13 16 each into three equal spaces, and the upper profiles 1 7 into six equal spaces, as shown by

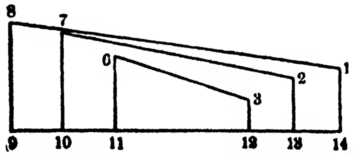


Fig. 190. Diagram of Solid Lines of Fig. 189

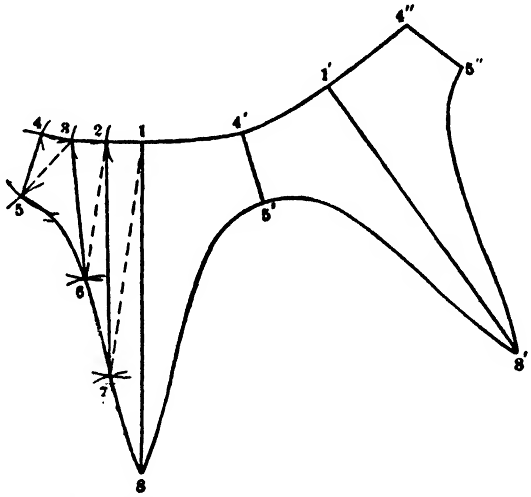


Fig. 192. Method of Developing Pattern from the Diagram of Triangles for Fig. 189

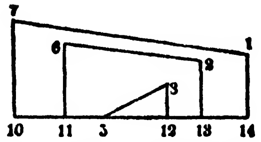


Fig. 191. Diagram of Dotted Lines of Fig. 189

the small figures 1 to 16. At right angles to 1 7, 8 12 and 12 16, and from the small figures in the profiles, draw lines intersecting the lines 1 7, 8 12 and 12 16 respectively, at points 24, 23, 22, 21, 20, 19, 18 and 17. Draw solid lines from 20 to 21, 19 to 22, 12 to 23, 18 to 24 and 17 to 25, and dotted lines from 8 to 21, 20

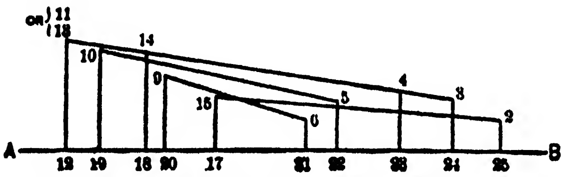


Fig. 194. Diagram of Solid Lines of Fig. 193

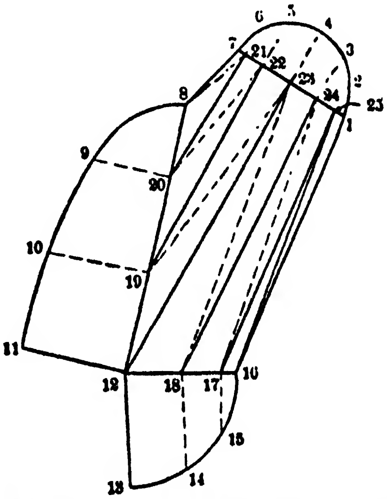


Fig. 193. Obtaining the Base Lines for Diagrams of Triangles

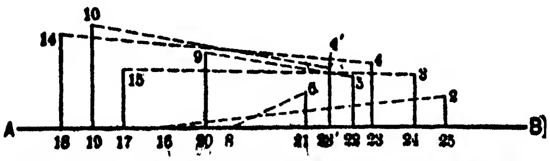


Fig. 195. Diagram of Dotted Lines of Fig. 193

to 22, 19 to 23, 18 to 23, 17 to 24 and 16 to 25. Then will these solid and dotted lines represent the bases of sections, the altitudes or hights of which will be obtained from the vertical lines in the three profiles.

In Fig. 194 are shown the sections on the solid lines in Fig. 193, and in Fig. 195 the sections on dotted lines in Fig. 193. These sections are obtained in precisely the same manner as was described in connection with Figs. 190 and 191, and will not be further explained here. Similar numbers in Figs. 194 and 195 correspond to similar numbers in Fig. 193.

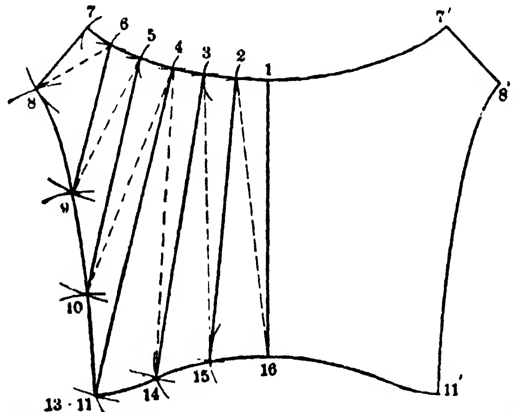


Fig. 196. Method of Developing the Pattern of Side Arms from the Diagram of Triangles

In Fig. 196 is shown the pattern shape for the side branch shown in Figs. 187 and 193, and is obtained in the same manner as described in connection with Fig. 192. First draw any vertical line, as 1 16 in Fig. 196, equal to 1 16 in Fig. 193. Then use alternately as radii first the spaces in the profile 1 7 in Fig. 193, then the length of the slant lines in Fig. 195, the spaces in the profile 13 16 in Fig. 193, then the length of the slant lines in Fig. 194, until the line 4 11 or 13 in pattern in Fig. 196 has been obtained. Starting from the point 13 11 in pattern, use alternately as radii first the divisions in the profile 11 8 in Fig. 193, then the length of the slant lines in Fig. 195, the divisions in the profile from 4 to 7 in Fig. 193, then the length of the slant lines in Fig. 194, the line 7 8 in the pattern in Fig. 196 being obtained from 7 8 in Fig. 193. A line traced through points thus obtained in Fig. 196, as shown by 1 7 8 11 13 16, will be the half pattern. Trace the other half opposite line 1 16, which will complete the full pattern for side branches. Laps to be allowed for riveting or seaming.

PATTERNS FOR TAPERING FORK

In the following method of how to lay out the patterns for the tapering fork shown in Fig. 197, A B C D E is the elevation of the fork, F being the diameter through E, and H and G the sections through A and D. The patterns for the pieces A and D are obtained the same as for any elbow piece, while E is simply a straight piece of pipe. The two forks B and C are of different sizes, but their patterns are developed by the same principles, the section on *a b* being the same in both forks. Similarly, if two or more pieces were used for the elbow or if the pipes H and G had their axis parallel with the axis of pipe F.

In Fig. 198 C D is an enlarged reproduction of C D in Fig. 197. Construct the half sections on 1″ 7″ and 1 7 by the usual method, as shown. Then, with

11′ in C as center, describe the semicircle 8 11 11″. At pleasure draw any desired curve, as 11″ 12 14, representing the half section on *a b* in Fig. 197. Divide the profiles L, F and J into the number of spaces shown, and draw perpendiculars to

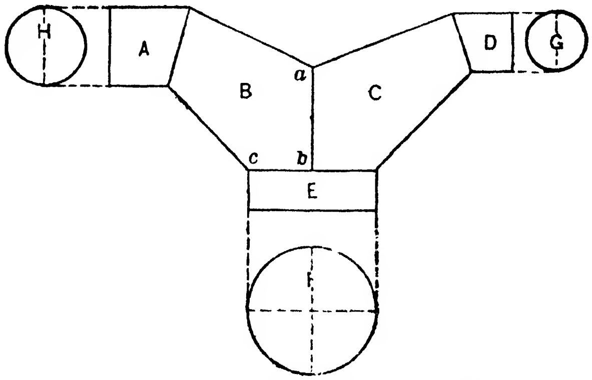


Fig. 197. The Fork and Elbows

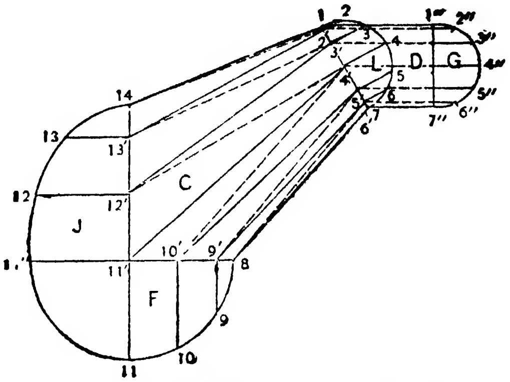


Fig. 198. Obtaining Measurements for Sections

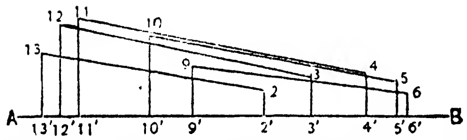


Fig. 199. Sections on Solid Lines in Fig. 198

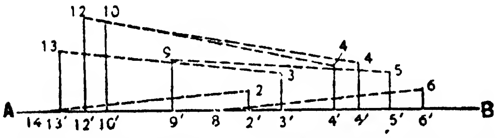


Fig. 200. Sections on Dotted Lines in Fig. 198

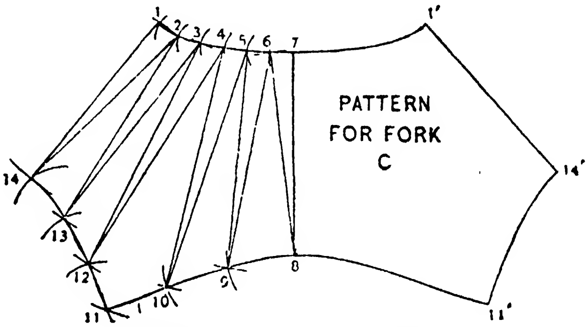


Fig. 201. The Pattern Shape

the base lines. From these points draw the solid and dotted lines shown. These represent the bases, and the various lines in the profiles L, F, J the altitudes of the sections which are constructed in Figs. 199 and 200 by the usual method. This being completed, proceed to lay out the pattern, as shown in Fig. 201.

REDUCING OFFSET IN PIPE WORK

In the illustration Fig. 202, is shown to what use a reducer is put. The reducer is shown by A and joins the large and small pipes at *b* and *a*. The joints at *a* and *b* are on horizontal lines, each being locked as shown at *e*, or they can be riveted, when heavy metal is used. The reducer can be developed the same as a scalene cone as shown. All unnecessary drawings are omitted, using only such lines as are actually required.

Draw the side view of the offset with the proper projection, hight and top and

bottom diameters, as shown by 1″ 5″ 5 1, Fig. 203. Extend the lines 1 1″ and 5 5″ until they intersect at A. Now extend the base line 1 5 and intersect it by a line drawn from the apex A at right angles to 1 5 at A^1. Draw the one half section on 1 5 as shown by 1 3 5, which divide into equal spaces as shown. With A^1 as center and radii equal to A^1 4, A^1 3, and A^1 2, draw arcs intersecting the base line 1 5 at 2′ 3′ and 4′, from which points draw lines to the apex A intersecting the upper line 1″ 5″ at 2″, 3″ and 4″.

Using A as center, with radii equal to A 1, A 2′, A 3′, A 4′ and A 5, draw arcs as shown. Set the dividers equal to one of the spaces in the half section and, starting on arc 5, or wherever

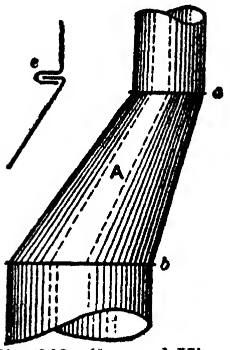


Fig. 202. General View of Reducer

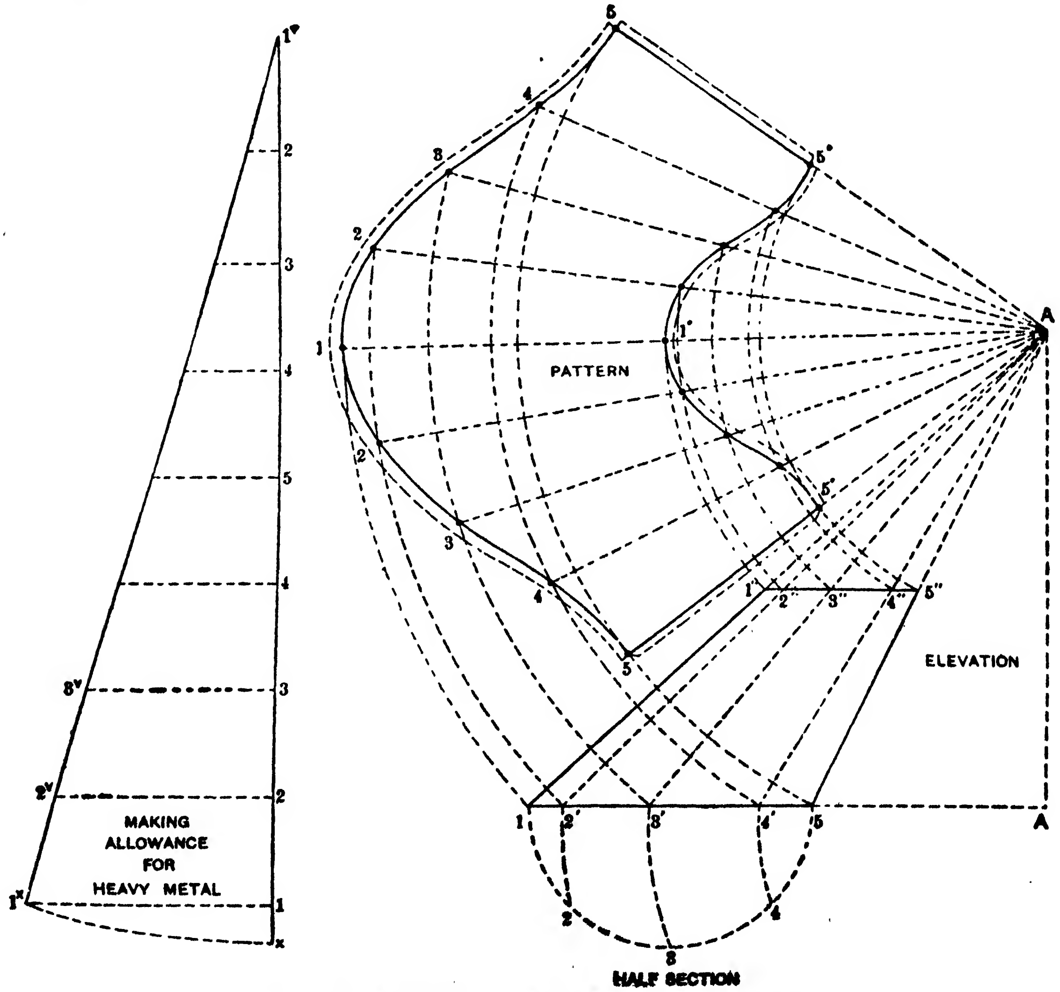


Fig. 203. Method of Developing Pattern for Offset

it is desired to have the seam, step from one arc to another as shown by 5 to 4 to 3 to 2 to 1, and then again to 5. From these small figures draw radial lines to

A, which intersect at 5° to 1° to 5° by arcs, struck from the center A, with radii equal to the various divisions on the line 1″ 5″. A line traced through these points as shown by 5 5° 1° 5° 5 1 5 will be the net pattern for the reducer.

Laps are allowed for seaming or riveting as shown by the dotted lines. If the reducer is made from heavy metal (which is usually riveted), allowance must be made for the thickness of the metal used, as follows: Take twice the girth of the half section and place it on the vertical line 1 X as shown from 1^v to 5 to 1. Assuming that the thickness of the metal in use is $\frac{1}{8}$ in., then take $7 \times \frac{1}{8}$ or seven times the thickness of the metal in use and place it as shown from 1 to X. Using 1^v as center and 1^v X as radius, draw an arc, which intersect by the perpendicular drawn from 1 at 1^x. Draw a line from 1^x to 1^v, and erect perpendiculars from points 2, 3, etc., thus obtaining 2^v, 3^v, etc. Then, instead of using the spaces in the half section to step off in the pattern as we have just done, one of the spaces on the slant line 1^x 1^v is used. This gives the necessary allowance to the girth on 5 1 5 in the pattern, after which proceed as before in obtaining the upper cut, 5° 1° 5°. This same rule also applies to making the necessary allowance for the thickness of the metal in the straight pipes *a* and *b* of the perspective sketch, Fig. 202.

RECTANGULAR AND OVAL PIPE FORK

The following is a method of finding miter lines of a rectangle running into an oval that is offset two ways, the opening to have same capacity at both miter connections. In this connection it may be proper to say that no matter what size the opening is at either inlet or outlet, or what form the article has, the principles hereinafter described are applicable to any case. In Fig. 204 let A B C D E F G be the elevation of the offset, the seams being at G A, E H and B C. Let I J K L be the plan of the rectangular base on the line A B in elevation, and M N O P the section of the oval on G F of one of the arms, while D C on the opposite arm has the same section. Though the plan is not necessary, so far as the pattern is concerned, the method of drawing it is given so that the student will understand its construction, if the occasion should arise. Bisect the short sides of the rectangle I L and J K in plan at points O^1 and O^2, through which draw indefinitely the line M^1 M^2.

Now, at right angles to A B in elevation, and from points F and G, drop lines intersecting the line M^1 M^2 in plan at points M^1 and O^1. At right angles to G F in elevation extend the center line N P in oval section, meeting G F at R. From R at right angles to A B drop a line indefinitely into plan, as R P^1. Take the

distance X N or X P in oval section, and, measuring from the center line M^1 M^2 in plan, place the distance on the line P^1 R, as shown by P^1 and N^1. Then through M^1 N^1 O^1 P^1 draw the figure shown. From R in elevation draw lines to

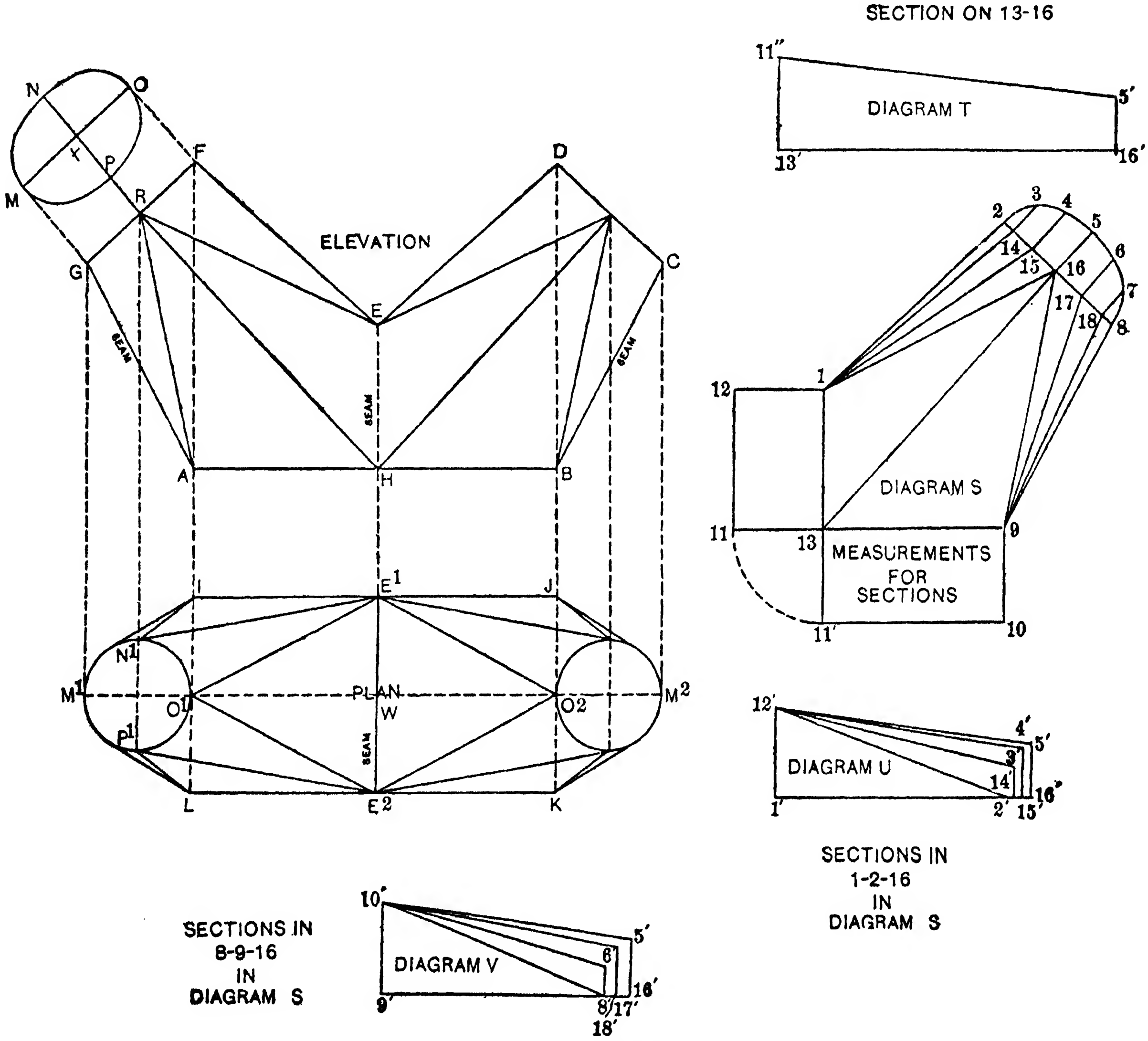


Fig. 204. Plan, Elevation, Measurements for Sections and Diagrams

A, H and E, representing the lines of the transition. In similar manner connect similar lines in plan. As the two arms are symmetrical, trace similar lines opposite in plan and elevation. Then will M^1 N^1 O^1 P^1 L E^2 K O^2 M^2 J E^1 I be the plan of the offset when viewed from the top.

As the pattern for one arm will answer for both, in diagram S let 1 2 8 9 13 be a reproduction of E D C B H in elevation. Take a tracing of M N O in the oval section and place it in diagram S, as shown by 2 5 8. In similar manner take

a tracing of E¹ J O² W in plan and place it as shown by 13 9 10 11′ in diagram S. It will now be necessary to obtain a section on E H in elevation, or 1 13 in diagram S; therefore from 1 and 13 and at right angles to 1 13 draw the lines 1 12 and 3 11, equal in length to 13 11′, as shown by the quarter circle, which is the one half width, E¹ W, in plan. Draw a line from 12 to 11 in diagram S. Then will 1 13 11 12 be the half section on E H in elevation or W E¹ in plan. Divide the half oval 2 5 8 in diagram S into equal spaces, as shown by the small figures 2 3 4 5 6 7 and 8, from which at right angles to 2 8 draw lines intersecting 2 8 at 14 15 16 17 and 18. From points 2 14 15 and 16 draw lines to point 1. From 16 draw a line to 13, and from points 16 17 18 and 8 draw lines to 9. Then will these lines represent the bases and the three sections on 2 8, 1 13 and 13 9 the altitudes, with which to construct the sections used in obtaining the pattern.

In diagram T draw any line, as 13′ 16′, equal to 13 16 in diagram S, and at right angles to 13′ 16′ in T draw the line 13′ 11″ and 16′ 5′, equal to 13 11 and 16 5 in diagram S. Draw the line 11″ 5′ in T, which will be the actual distance on the finished article on 13 16 in S. In similar manner draw any line, as 1′ 16′ in diagram U, upon which place the various lengths shown in diagram S by 1 2, 14, 15 and 16, as shown in diagram U by 1′ 2′, 14′ 15′ and 16′. At right angles to 1′, and from points 1′ 14′ 15′ and 16′, draw the lines 1′ 12′, 14′ 3′, 15′ 4′ and 16′ 5′, equal in length to 1 12, 14 3, 15 4 and 16 5 respectively in diagram S. Then draw lines in diagram U, as shown by 12′ 2′, 12′ 3′, 12′ 4′ and 12′ 5′, which will represent the actual distances on lines having similar numbers in S. Proceed in precisely the same manner for sections in 8 9 16, as shown in diagram V by similar figures.

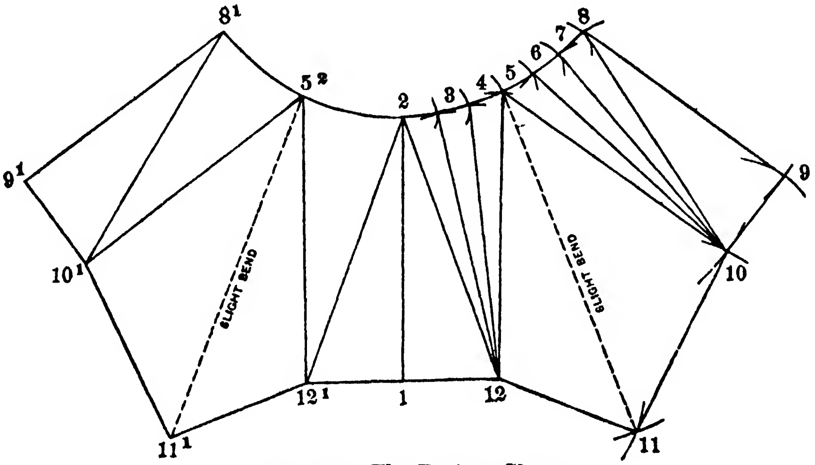


Fig. 205. The Pattern Shape

For the pattern proceed as follows: Draw any vertical line in Fig. 205, as 1 2, equal to 1 2 in diagram S in Fig. 204. Take the distance from 1 to 12 and place it from 1 to 12 in Fig. 205 at right angles to 2 1. Draw the line from 2 to 12, which will equal 2′ 12′ in diagram U in Fig. 204. Now with radii equal to 12′ 3′, 12′ 4′ and 12′ 5′, and with 12 in Fig. 205 as center, describe arcs, as shown by

3 4 and 5. Set the compasses equal to the spaces into which the half oval in diagram S in Fig. 204 is divided, as shown by 3 4 and 5, and starting at 2 in

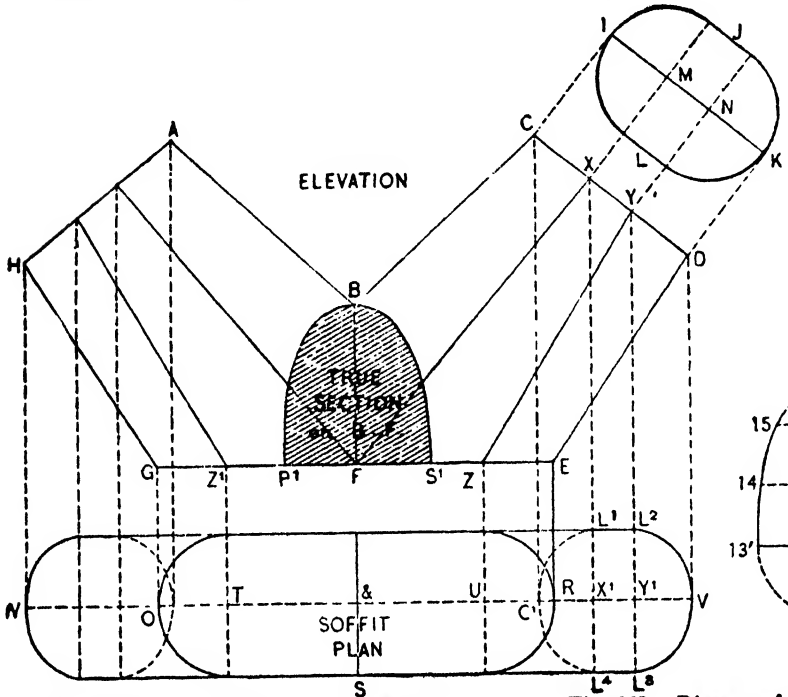


Fig. 206. Plan, Elevation and Sections

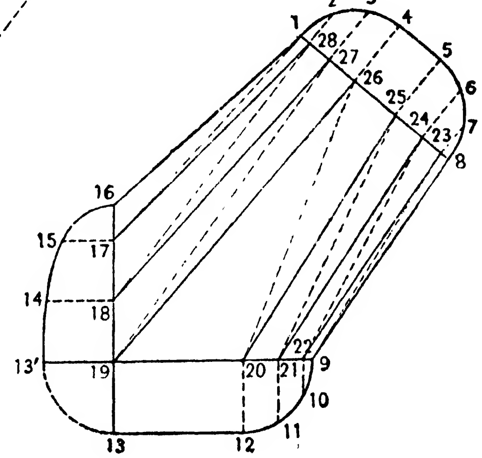


Fig. 207. Diagram for Obtaining Measurements for Sections

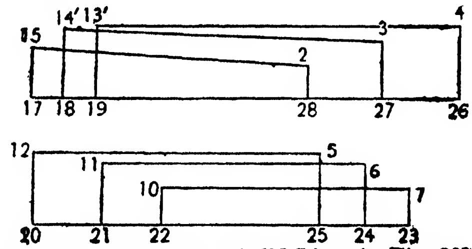


Fig. 208. Sections on Solid Lines in Fig. 207

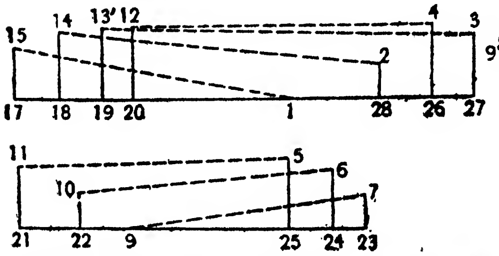


Fig. 209. Sections on Dotted Lines in Fig. 207

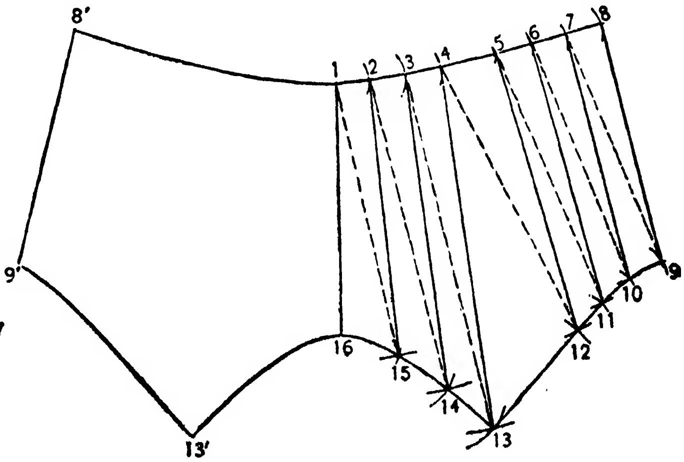


Fig. 210. The Pattern Shape for One Arm

Fig. 205 intersect the arc 3, then use 3 as center and intersect the arc 4, then 4 as center and intersect 5 and draw a line from 5 to 12. With 12 as center, and 12 11

in S in Fig. 204 as radius describe the arc 11 in Fig. 205. Then with 5 as center, and 5′ 11″ in diagram T in Fig. 204 as radius, intersect the arc 11 in Fig. 205, as shown.

Next, using 11 as center, and 11′ 10 in S in Fig. 204 as radius, describe the arc 10 in Fig. 205, which intersect with an arc struck from 5 as center, and 5′ 10′ in diagram V in Fig. 204 as radius.

With radii equal to 10′ 6′, 10′ 7′ and 10′ 8′, and 10 in Fig. 205 as center, describe the arcs 6 7 and 8, which intersect with divisions equal to 6 7 and 8 in the half oval in S in Fig. 204. With 8 9 as radius, and 8 in Fig. 205 as center, describe the arc 9, which intersect with an arc struck from 10 as center, with a radius equal to 10 9 in S in Fig. 204. Trace a line through intersections thus obtained in Fig. 205, then will 1 2 5 8 9 10 11 12 be the half pattern. Trace the other half opposite the line 1 2, then will 8^1 5^1 2 5 8 9 10 11 12 1 12^1 11^1 10^1 9^1 be the full pattern.

In Fig. 206 is shown a similar fork, excepting that the section of the large pipe is oval, or rather rectangular with semicircular ends. The principles of developing the patterns are identical to the foregoing and as shown in Figs. 207, 208, 209 and 210.

FINDING THE TRUE ANGLE IN A FLARING OBJECT

To find the true angle between the flaring sides of an irregular hopper, proceed as follows: In the illustration, Fig. 211, A B C D represents the base of the hopper and E F G H the top. It is now desired to find the true angle between the sides E F B A and G F B C, which join on the hip line B F. Draw a c at right angles to the hip line F B in plan. Then construct an oblique elevation on F B in plan in which the true length of one of the hips will be shown, as follows: Parallel to F B draw F^1 B^1, which intersect by two lines drawn from F and B in plan at right angles to F B. Extend F F^1 to K, making F^1 K equal to the hight of the hopper in elevations. Draw K B^1,

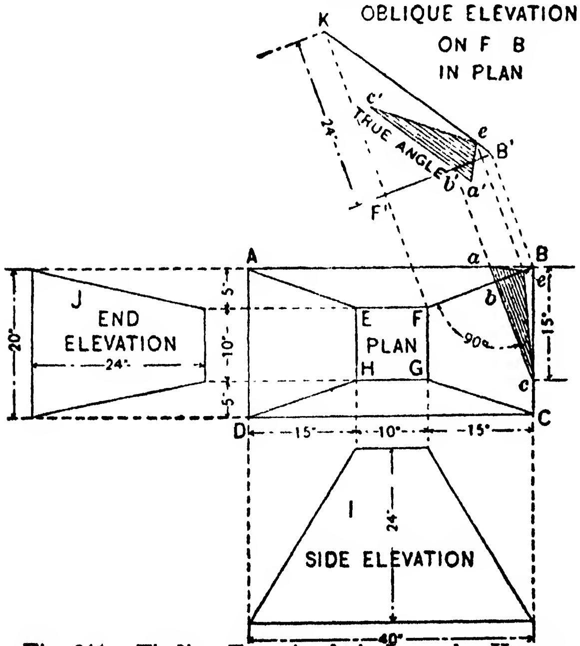


Fig. 211. Finding True Angle in Irregular Hopper

which is the true length of the hip. At right angles to F B extend c a, meeting F^1 B^1 at b'. From this point, at right angles to K B^1, draw b' e. Through b',

parallel to K B^1, draw a' c', making b' a' and b' c' equal respectively to b a and b c in plan. Connect the points v' to e to c'. Then will the shaded portion a' e c' be the true angle between the sides of the hopper a and c at right angles to the hip line in plan and oblique elevation. e' in plan is obtained by dropping a line parallel to c b' from e, and a e' c in plan is the horizontal projection of the true angle, but it is not necessary to find this in practice.

SOME SHORT RULES FOR DEVELOPING PATTERNS

Fig. 212 shows an elbow at any angle, the rise of the miter line of which is equal to a b and its section is a rectangle, as shown by A. To obtain this pattern by

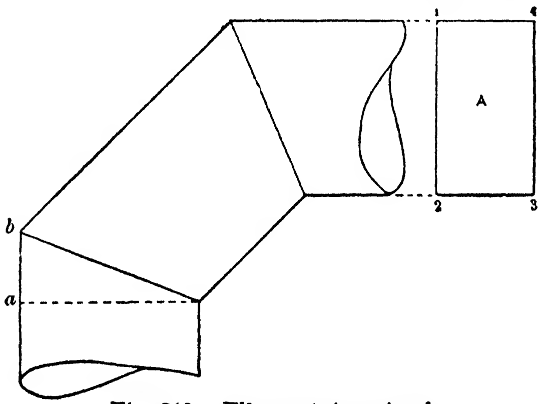


Fig. 212. Elbow at Any Angle

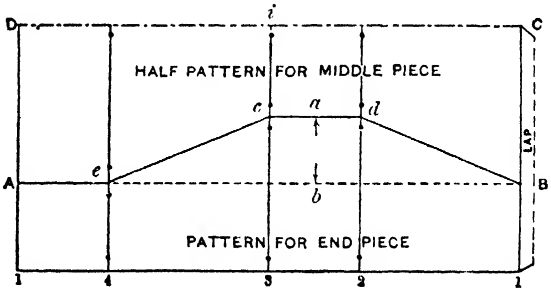


Fig. 213. Pattern for Elbow Shown in Fig. 212

the short rule take the girth of A and place it on the proper size sheet of metal, as shown from 1 to 1 in Fig. 213, the seam in this case to come on the corner 1 in

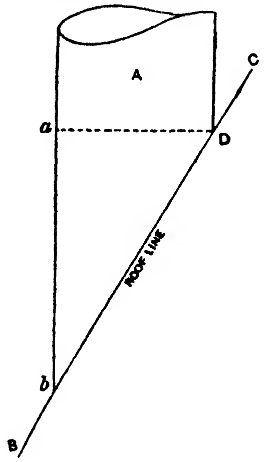


Fig. 214. Cylinder on Inclined Roof

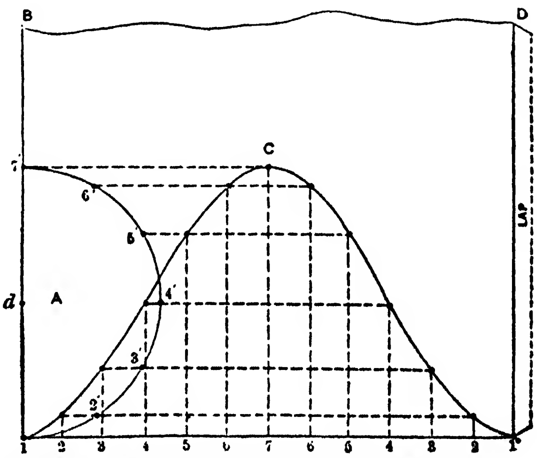


Fig. 215. Pattern for Cylinder on Inclined Roof

A in Fig. 212. Make 1 A and 1 B in Fig. 214 equal to the length of the end piece on the throat side and draw a line from A to B. Take the rise of the miter

line *a b* in Fig. 212 and place it, as shown from *b* to *a* in Fig. 213, and through *a* draw the horizontal line *c d*. A *e c d* B is then the desired cut. Take the distance A 1 and place it, as shown by *c i*, and through *i* draw the line D C; 1 A *a* B 1 is then the pattern for the end piece and A *a* B C D the one half pattern for the middle piece, which, however, can be made any desired length. By tracing 1 1 C D opposite the line C D the full patterns are obtained, to which edges must be allowed for seaming and riveting.

Fig. 214 shows how to obtain the pattern for a cylinder fitting on an inclined roof. A represents the cylinder and B C the pitch of the roof. From D at right angles to the pipe draw D *a*. Then *a b* becomes the rise of the miter line. Now cut a piece of metal equal to the girth of the round pipe A, to which edges have been allowed, as shown by 1 1° D B in Fig. 215, and divide the girth 1 1° into any convenient number of even spaces. Use the metal T-square and erect lines, as shown. Place the rise *b a*, in Fig. 215, as shown, from 1 to 7′ in Fig. 215. Bisect 1 7′ and obtain *d*, which use as a center and describe the semicircle 1 4′ 7′, which divide into half as many spaces as contained in 1 1°, as shown by similar figures. With the metal T-square from the various intersections in A intersect vertical lines previously drawn. Through these intersections draw the miter cut 1 C 1°. Then B 1 C 1° D is the desired pattern. The rule given in Fig. 215 can be applied whether the pipe A in Fig. 214 is square, rectangular or round.

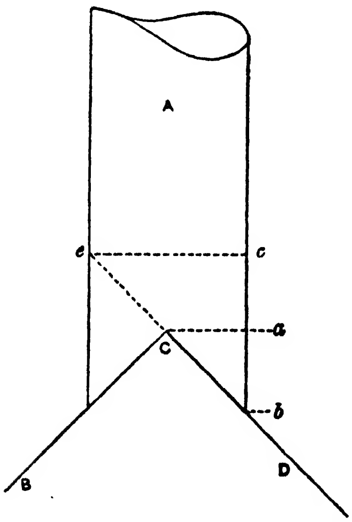


Fig. 216. Cylinder on Double Pitched Roof

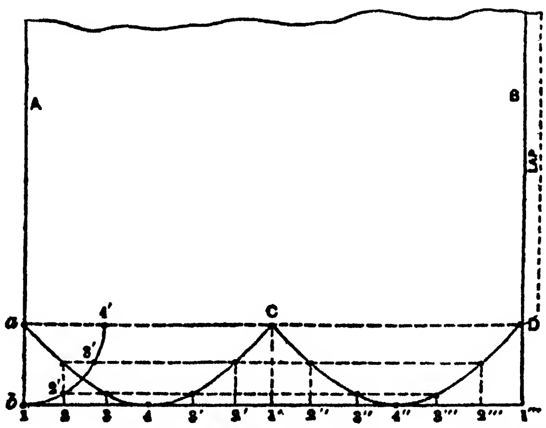


Fig. 217. Pattern for Cylinder on Double Pitched Roof

In Fig. 216 is shown the cylinder A mitering on a double pitched roof, shown by B C D. From C draw the horizontal line C *a*. Then *a b* is the rise of the miter line. Obtain the girth of A in the usual manner and cut a piece of metal of the required size, as shown in Fig. 217. Space the girth into an even number of

spaces, as shown from 1 to 4, 4 to 1′, 1′ to 4″ and 4″ to 1‴, and with the metal T-square draw lines, as shown. Take the distance from *b* to *a*, in Fig. 216, and place it, as shown, from *b* to *a*, in Fig. 217. With *a* as a center and *a b* as radius draw the quarter circle *a b* 4′ which divide into one fourth as many spaces as there are spaces in 1 1‴. From the various intersections in the quarter circle draw lines parallel to 1 1‴ until they meet similar vertical lines, as shown. A line traced through points thus obtained, as shown by *a* C D, will be the desired pattern. In the previous problem, Fig. 215, a semicircle was used, because the cylinder intersected a roof of one inclination, as shown in Fig. 214. In this problem but one quarter of a circle is used because the cylinder A, in Fig. 216, miters against a double pitched roof. This is easily proved by extending the line D C, in Fig. 216, until it cuts the side of the cylinder at *e*. From *e* draw a line to *c*. Now *c a* and *a b* are equal, and *a* would be the center point with which to draw the semicircle, radius of which is equal to *a b* or *a c*, as was done in Fig. 215. In Fig. 217 a quarter circle is only used, because C *b*, in Fig. 216, is one half of *b e*.

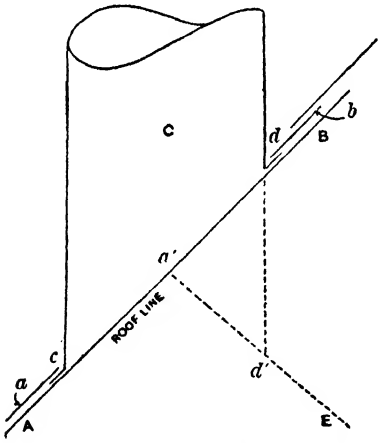


Fig. 218. Sectional View of Roof Flange

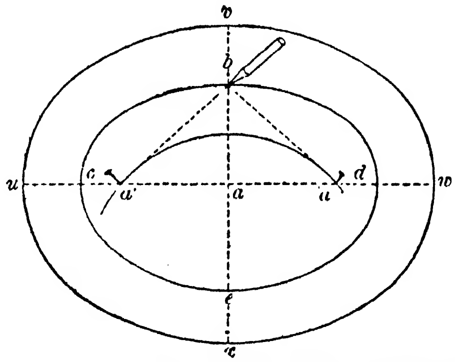


Fig. 219. Pattern for Roof Flange

When a roof flange is required to fit around a cylinder butting against a single or double pitched roof a simple and quick method for obtaining same is shown in Fig. 219. Let A B in Fig. 218 be the pitched roof, against which the cylinder C miters; *a b* represents the roof flange soldered to the cylinder at *c* and *d*. Now knowing the diameter of the cylinder C and the length of the opening *c d*, the flange is developed as follows:

Draw any horizontal line in Fig. 219, as *c d* equal to *c d* in Fig. 219. Bisect *c d* in Fig. 219 and obtain *a*, through which at right angles to *c d* draw *e b*, making *a b* and *a e* each equal to one half the diameter of the pipe C in Fig.

218. With a radius equal to one half of *c d*, as *a d* or *a c*, and with *e* as center, describe an arc cutting the line *c d* at *a'* and *a''*. Drive a nail at *a'* and another at *a''*. Tie a piece of spool wire around these two nails long enough so that when the wire is drawn taut it will reach point *b*. Now, using a pencil or scribe awl, draw the ellipse, shown by *c b d e*. Knowing the width of the flange *a* or *b* in Fig. 218, set the dividers equal to this distance and scribe a line parallel to *e d b c*, as shown by *u v w x* in Fig. 219. These flanges are usually made in two parts with a seam on *u c* and *d w*, which enables the flange to be placed around the cylinder C in Fig. 218 from both sides.

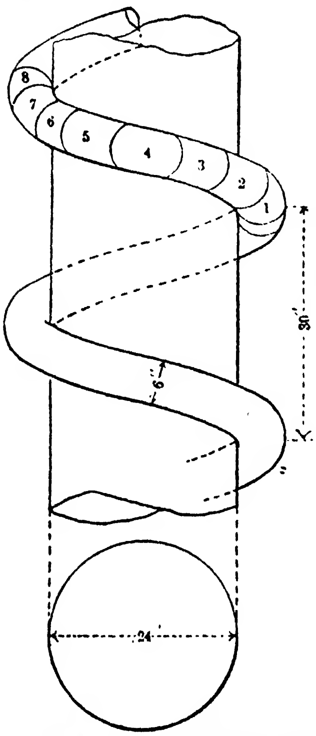
When the cylinder C in Fig. 218 butts against a double pitched roof, shown by A *a* E, it is only necessary to take the distances *c a'* and *a' d'* and place them as shown by *c a* and *a d* in Fig. 219 and proceed as before. In this case a bend would be made along *v x* in the pattern to correspond to the angle A *a'* E in Fig. 218. By a little study and foresight time can be saved by using the foregoing rules when developing sheet metal work of this kind.

PATTERNS FOR A PIPE TO DESCRIBE A HELICAL CURVE ABOUT A CYLINDER

A pipe 6 inches in diameter is required to wind around a cylinder 24 inches in diameter so that the rise at each revolution shall be 30 inches, as shown in Fig. 220, the number of pieces in each revolution being 16. It can be readily seen that the pattern will not be the same as that of an ordinary elbow and it will be something like what is shown at A, the throats of the two miters being marked by the arrow points. What is desired particularly is how much the throat of the miter at one end of a piece is placed to one side of that at the other in order to produce the required twist.

Perhaps it would be more accurate, however, to say that each miter in itself is the same as would be required for an elbow of the same curve, but that the wind is produced by theoretically turning one end of each piece of the elbow axially upon the other end, thereby throwing the throats of the two miters out of line. This is accomplished in the pattern by shifting the position of the stretchout for one end of the pattern a sufficient amount above or below that of the other, as indicated. The problem consists, then, in determining just how much to turn the throat of one miter around from that of the other, or, in other words, in finding the exact angle between the lines of the two throats, as seen in an end view of a section of the pipe.

In the case of a helix consisting of a great number of pieces to each revolution, say 16 or more, the amount of turn in each piece is so slight that the desired result might be practically obtained by judicious manipulation in the process of putting the pieces together. The twist is further decreased of course as the pitch, or rise, of the spiral decreases. The conditions given in the sketch, Fig. 220, are such, however, as to make the difference in the positions of the throats quite appreciable. There are several ways in which this difference may be derived from accurately made drawings. Probably the simplest way is that of developing a correct elevation of the helical curve. This may be properly accomplished by first drawing a plan, as shown in the lower part of Fig. 221, above which the elevation is projected in the usual way.



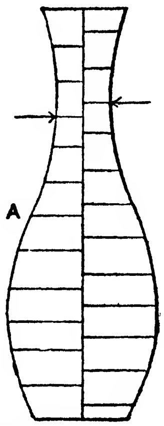


Fig. 220. A Sketch of the Problem

In this figure A B C shows a half plan of the vertical cylinder, around which the winding pipe, made up of the required number of pieces, is drawn, as though laid in a horizontal plane. In drawing the several pieces of the pipe on the plan, it is best to divide the circumference of the 24-inch cylinder so that the middle of one of the pieces (not a miter) shall fall on the center line of the plan and elevation. As all the pieces required to form the spiral must necessarily be alike, this arrangement will give a normal elevation of the central piece, from which its correct length may be measured and its miter lines obtained. Therefore, divide the semicircumference A B C of the plan into 16 equal spaces and through the alternate points *a*, *b*, *c*, etc., draw lines from the center D, extending them to represent the miters of the small pipe. From B set off on the center line B D extended, the diameter and semidiameter of the small pipe, as shown at E and F. Through B, F and E draw lines parallel to A C, representing the sides and axis of the pipe, continuing them till they intersect the miter lines *d* G and *e* H. Now, from D as center with D G as radius draw a semicircle, shown dotted, cutting the several miter lines as shown. Connect the several intersections, as G J, J K, etc., thus obtaining the outer line of the spiral pipe, and continue the inner axial lines parallel with the outer line from the points of intersections with *d* G, all as shown. From each of the points of intersection of the axial line with the several miter lines of the plan, as 1, 2, 3, etc., project lines upward through the elevation indefinitely.

It will now be necessary to divide a space of 30 inches in the vertical hight of the cylinder into as many spaces (16) as there are pieces in one complete revolution of the helical pipe. The same result will be obtained if desirable, by dividing 15 inches of the hight into eight spaces and using half the plan. Therefore, at any

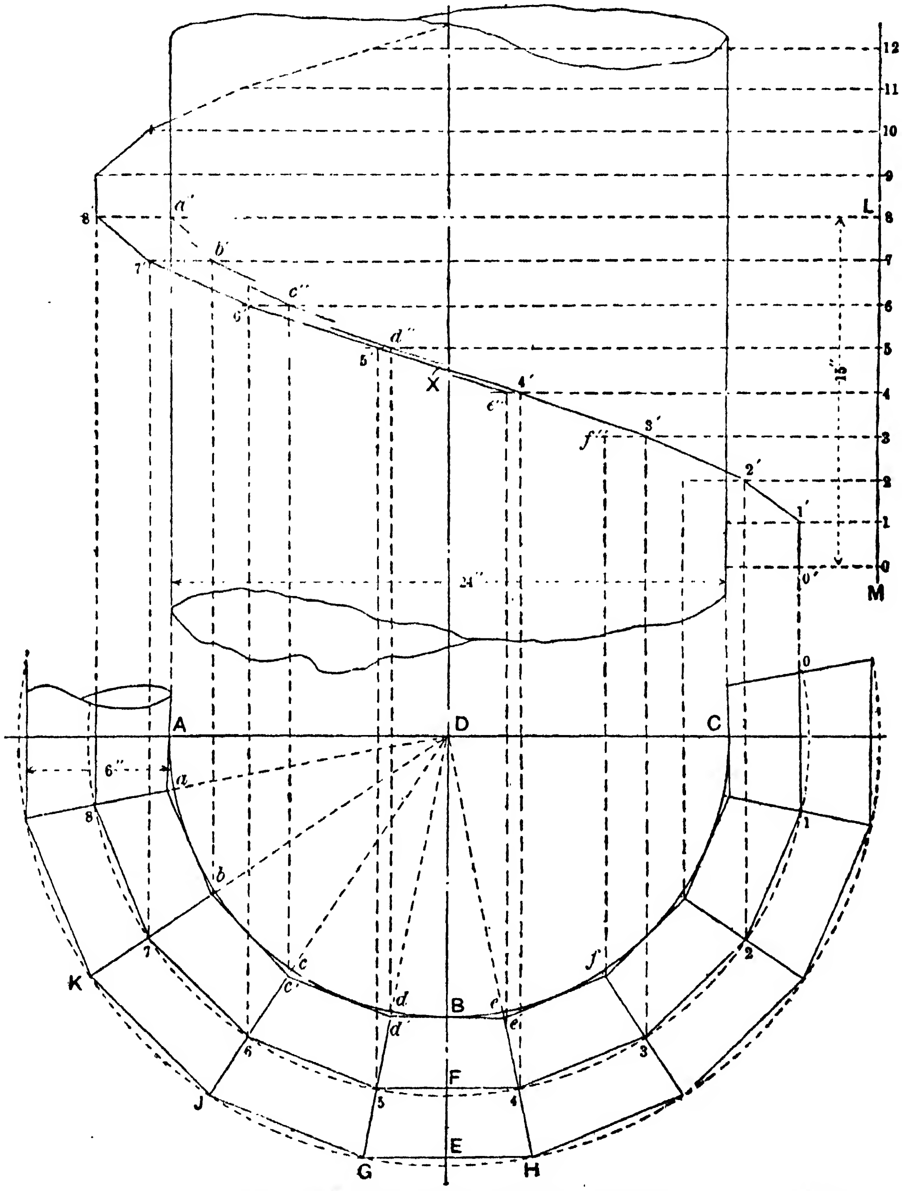


Fig. 221. Plan and Elevation of the Cylinder and Winding Pipe, Showing Method of Developing the Lines of the Spiral Curve

convenient point outside the elevation of the cylinder draw any line, as L M, 15 inches long, and divide the same into eight equal spaces. From each of the points of division in L M draw horizontal lines across the elevation, intersecting each with the line of corresponding number just drawn from the plan. It should be noted

that the numbers of the points in the plan and in the line L M should increase in the same direction, as, for instance, in the direction of the rise of the pipe. Straight lines connecting the adjacent points of intersection in the elevation, as shown by 0′ 1′, 1′ 2′, 2′ 3′, etc., will then represent a correct elevation of the axis of the spiral pipe throughout one half a revolution, and the line 4′ 5′ will show the correct length and inclination of the axis, or center line, of the middle piece, shown by 4 5 of the plan. Upon this line 4′ 5′ may be constructed the complete elevation of one piece if desired, but as it is not really necessary in obtaining the final result it has been omitted.

An inspection of the plan will now show that while the lines 3 4, 4 5, etc., of that view are inclined at the angle shown by 4′ 5′ of the elevation, the lines *e* H, *d* G, *c* J, etc., are drawn horizontally through the intersections, or meeting points, 4, 5, 6, etc., of the axes of the several pieces, and that these lines when extended to D intersect the vertical axis of the large cylinder, not at one point, as the plan might seem to indicate, but at various hights, shown respectively by the figures in L M. If, therefore, vertical lines be erected from the points *e*′, *d*′, *c*′, etc., representing the throats of the miters in the plan, to intersect with the horizontal lines of corresponding number of the elevation—that is, from *e*′ of the plan to intersect with the line from 4 in L M, and from *d*′ with 5 in L M, etc.—the several points so obtained will show the true positions of the throats of the several miters in the elevation, as indicated by *c*″, *d*″, *c*″, etc. If now lines be drawn from *e*″ and *d*″ parallel to 4′ 5′ toward the center line, the distance between these lines shown at X will give the exact amount that the stretchout for one end of the pattern must be shifted above or below that of the other end to produce the desired pattern for one piece of the spiral elbow.

Inasmuch as the distances 4 5, 5 6, etc., of the plan in Fig. 221 do not represent the true lengths of the axes of the pieces on account of the inclination of those lines, as before mentioned, it will be necessary before attempting to develop the pattern that a correct plan of one piece be drawn. Therefore, draw the line D E of Fig. 222 equal in length to D E of Fig. 221, and on this locate the points B and F correspondingly. Through the point F draw the center line 4′ 5′ at right angles to D E, making it equal in length to 4′ 5′ of the elevation, Fig. 221, and from D draw lines through points 4′ and 5′ indefinitely, constituting the true miter lines. Upon 4′ 5′, extended to any convenient point, and with C as center and with B F as radius, describe the profile as shown. Beginning now at the point 0, corresponding to the throat B of the miter, divide the profile into any suitable number of equal spaces and set off a stretchout of the same on D E, extended as shown

toward S. Measuring lines for the miter at one end of the piece may now be drawn to one side, as to the left, for the pattern of that end of the piece, after which the stretchout must be repeated on the same line E S, beginning at a point, n, the distance of which below 0 of the other stretchout, is equal to the distance X obtained in the elevation, Fig. 221. From the points of the second stretchout the measuring lines are now drawn to the right and the remaining operations necessary to complete the pattern conducted in the usual manner. Of course, that portion of the right half of the pattern which projects beyond the other side, shown at m, must be transferred to the top so as to make a straight joint at the throat, where the usual lap will be allowed. In putting the miters together great care must be taken to bring the point h at the left end of one piece to the point k at the right end of the adjacent piece.

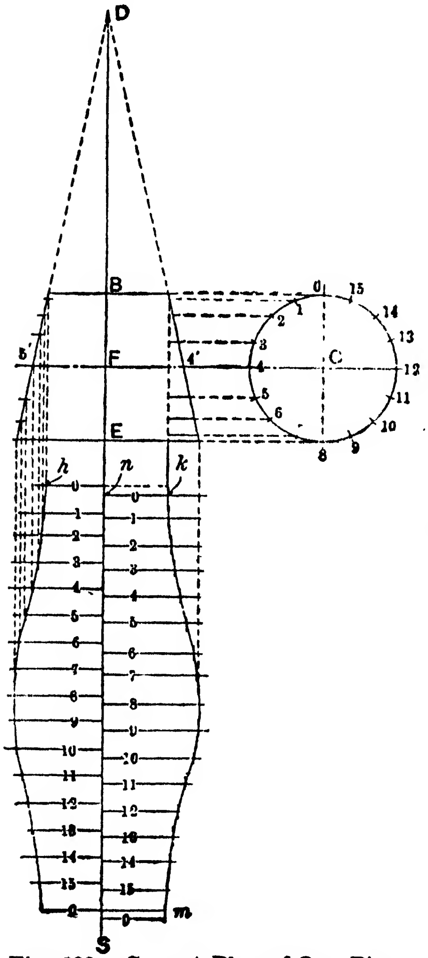


Fig. 222. Correct Plan of One Piece, Showing Manner of Laying off Stretchout

Much of the work described in connection with Fig. 221 and shown therein is done for explanatory reasons and can be omitted in actual practice. After the plan A B C and the line L M have been divided into the requisite number of spaces, the parts of the drawing really necessary to obtain the final result are those portions between the lines d G and e H of the plan and between 4′ and 5′ of the elevation. It must also be noted in forming the pieces that that portion of the pattern from 0 to 8 of the stretchout forms the under side of the piece, for if formed so as to bring it on the upper side, the joining of the miters as above described would produce a spiral inclining downward toward the left instead of upward, as in Fig. 221.

PATTERN FOR TWISTED TRANSITION ELBOW

The drawing shown by Fig. 223 is for some piping in a grain elevator. The connections of this must be made in the elbows and the flare on the side of the top elbow must be made all on one side, so as to pass the rafters in the building.

By referring to the front elevation, it will be seen that three different fittings are used. A shows a pieced elbow, shown in side view by A^1, B is a transition piece joining the round elbow at *a*, shown in side view by B^1, while C is a twisted transition elbow, 20 inches square at *b*, flaring to one side, as shown, to connect with a pipe 9×35 inches, and is shown in side view by C^1. The pieced elbow at A is cut in the usual manner, while the transition B is developed as shown.

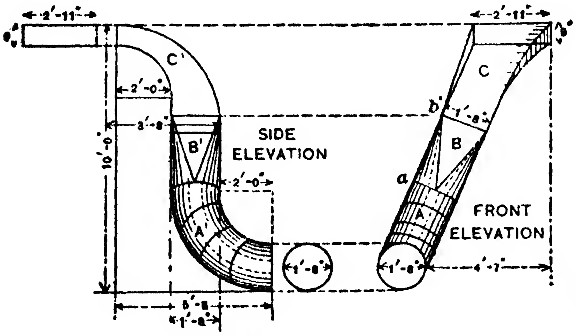


Fig. 223. Dimensions and Views of the Problem

In laying out the elbow C, to avoid a confusion of lines, which would occur in so small a space, enlarged diagrams are shown in Fig. 224, in which 1 2 12 11 is the side of the elbow shown in front by 1, 2, 2°, 1°, 12° and 10, which represent similar shapes, as shown by C^1 and C respectively in Fig. 223. The first step in Fig. 224 is to divide the two curves in side view into an equal number of spaces, as shown by the small figures 2 to 12 on the outer curve and 1 to 11 on the inner curve. At right angles to 1 2 in side elevation and from points 2 to 12 on the top curve, draw horizontal lines intersecting the top of the elbow in front elevation at 2, 4, 6, 8 and 10 on the line 2 10, and at 2°, 4°, 6°, 8°, 10° and 12° on the line 2° 12°, as shown. In similar manner, at right angles to 1 2 in side elevation and from points 1 to 11 on the bottom of the elbow, draw horizontal lines intersecting the bottom of the elbow in front elevation at 1, 3, 5, 7 and 9 on the line 1 9, and at 1° 3° 5° 7° 9° and 11° on the line 1° 11°, as shown. In this connection it should be understood that the corner or miter lines 2 10, 1 9 and 2° 12°, 1° 11° are drawn at pleasure after the dimensions are obtained; but when once drawn remain fixed lines.

For the pattern for the top of the elbow proceed as follows: At right angles to 2 2° in front draw the line 12′ 2′, upon which place the stretchout of the top curve 2 to 12 in side elevation, as shown by 2′ to 12′ on the line 12′ 2′. At right angles to 2′ 12′ and from the small figures draw lines, as shown, which intersect with lines, not here shown, drawn from points having similar numbers on the miter lines 2 10 and 2° 12° at right angles to 2 2° in front elevation, thus obtaining similarly numbered intersections in A. A line traced through the points thus obtained, as shown by 2 2° 12° 10, will be the pattern for the top of the elbow.

For the pattern for the bottom draw a line, 1′ 11′, at right angles to 10 9°, upon which place the stretchout of the bottom curve 1 11 in side elevation, as shown by

similar numbers on 1′ 11′. At right angles to 1′ 11′ and from the small figures draw lines, as shown, which intersect with lines, not here shown, drawn from points having similar numbers on the miter lines 1 9 and 1° 11° in front elevation

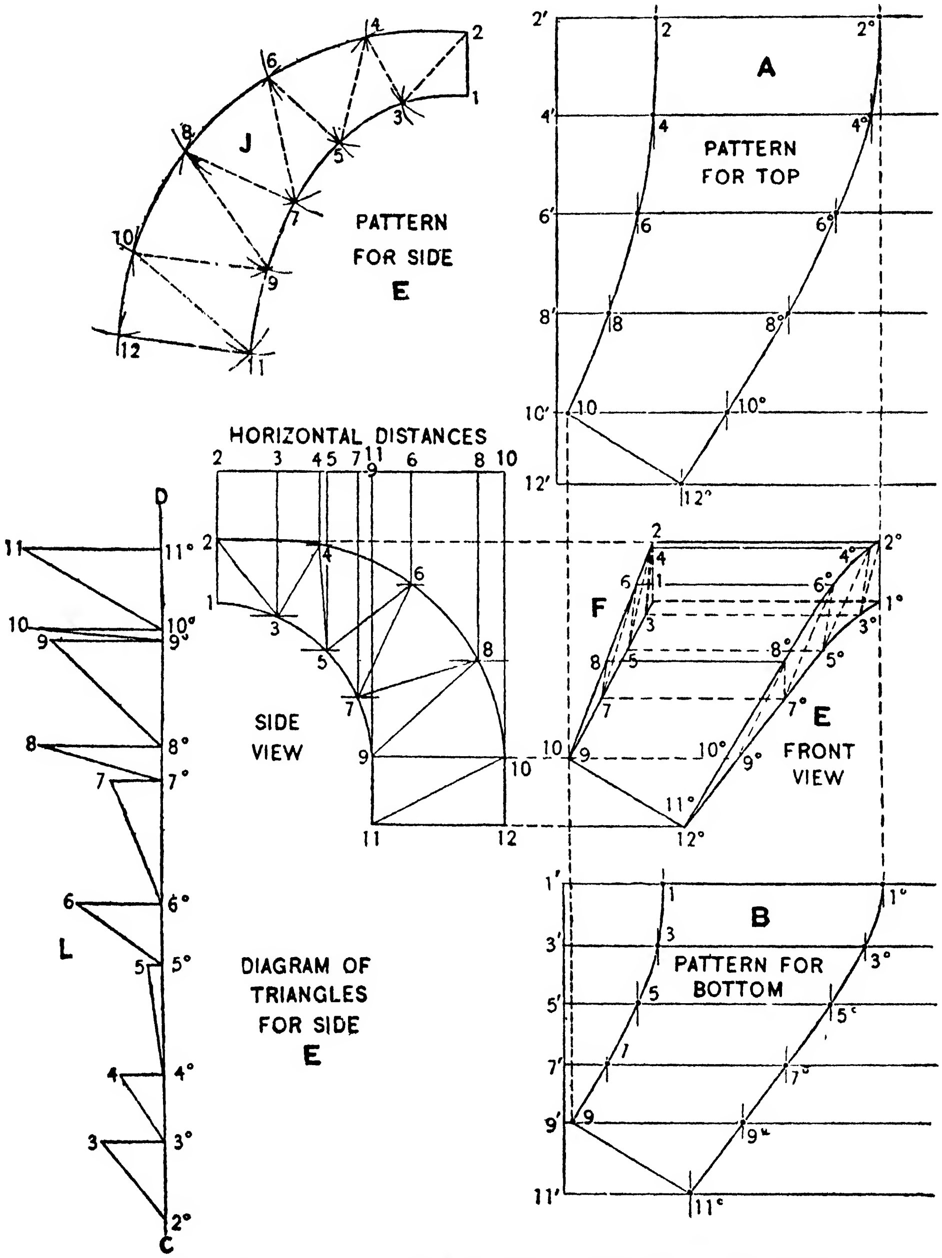


Fig. 224. Side and Front Views, Diagrams of Triangles and Patterns

at right angles to 9 9°, thus obtaining similar numbered intersections in B. A line traced through points thus obtained, as shown by 1 1° 11° 9, will be the pattern for the bottom of the elbow.

The patterns for the sides E and F will be developed by triangulation. As the method used for obtaining the pattern E can also be applied to F, only the side E will be developed. Now, from the various points in the side view connect lines 2 to 3 to 4 to 5 to 6, 7, 8, 9, 10 and 11, as shown. In similar manner, in the side E in front connect points 2° to 3° to 4° to 5° to 6°, 7°, 8°, 9°, 10° and 11°, as shown, and proceed in the same manner for the side F by connecting 2 to 3 to 4 to 5 to 6, 7, 8 and 9, all as shown. Then will the lines shown in E and F represent the bases of the triangle which will be constructed, and the horizontal distances between the points in the side view the altitudes or hights. To obtain these horizontal distances in the side view draw any horizontal line, 2 10, on which erect perpendicular lines drawn from the various points in the side view, as shown, thus obtaining similarly numbered figures on 2 10 corresponding to those in the side view.

For the diagram of triangles for E erect any line, as C D, as shown. Now take the various distances in the dividers in the side E, as from 2° to 3°, 3° to 4°, 4° to 5°, 5° to 6°, 6° to 7°, 7° to 8°, 8° to 9°, 9° to 10° and 10° to 11°, and place them on the line C D, as shown by distances having similar numbers. At right angles to C D draw lines from the various points, as shown. Then take the various horizontal distances and place them on similar lines just drawn. For example, take the horizontal distance 2 3 and place it, as shown, from 3° to 3 in the diagram of triangles, and draw a line from 3 to 2°. In similar manner take the horizontal distance from 3 to 4 and place it, as shown, from 4° to 4 in the diagram of triangles and draw a line from 4 to 3°. In this manner obtain all of the triangles for the twisted side E. Then, using these triangles and the patterns for the top and bottom, the miter lines of which show the developed lines for the corners of the elbow, all is ready to strike out the pattern for the twisted side E in front. Thus, in J draw any line, as 1 2, equal to 1° 2° in E. Now, with 1° 3° in B as radius and 1 in E as center describe the arc 3, which intersect by an arc struck from 2 as center with 2° 3 in L as radius. With 2 in J as center and 2° 4° in A as radius describe the arc 4 in J, which intersect by an arc struck from 3 as center and 3° 4 in L as radius. Proceed in similar manner for the balance of the pattern, using alternately, first the divisions on the miter cut 1° 11° in B, then the proper numbered slant line in L, the divisions on the miter cut 2° 12° in A, then the proper numbered slant line in L, until the last line, 11 12 in J (which is obtained from 11 12 in the side view), is obtained. A line traced through points thus obtained, as shown by 1 2 12 11 in J, will be the pattern for the side E. In precisely the same manner obtain the pattern for side F.

PATTERN FOR COMPOUND CURVED TAPERING ELBOW

The following exemplifies the correct method of laying out the patterns for a reducing elbow having a compound curve, as shown in Fig. 225. The elbow curves 90 degrees in plan and reduces from 15 to 10 inches. The center of the 10-inch pipe is placed 18 inches below the 15-inch opening in the blower.

First draw a correct plan and elevation of the elbow when viewed in the direction of the arrow in Fig. 225. This has been done in Fig. 226. With a radius of 2 feet 5 inches and A as center, draw the quarter circle B C. As the elbow is to be six pieced, divide B C into five spaces, placing two halves, as shown, from B to *a* and C to *e*. Through *a*, *b*, *c*, *d* and *e* draw radial lines, as shown. From B and C draw vertical and horizontal lines, respectively, intersecting the lines A I and A E at *m* and *f*. Take the distance of A *m* and place it on the balance of the radial lines, as shown by *h*, *i* and *j*. Draw lines *m j*, *j i*, *i h* and *h f*. Make the distances B J and B J° each equal to 5 inches and draw vertical lines from J and J°, intersecting the miter line at I and I°. In a similar manner make the distances C D and C D° each equal to 7½ inches and draw horizontal lines, intersecting the miter line at E and E°. These two end sections of the elbow are parallel pieces of pipe, the patterns for which are obtained as in ordinary elbow work, the half sections of the 10 and 15-inch pipes being shown, respectively, by *m* in elevation and C in plan.

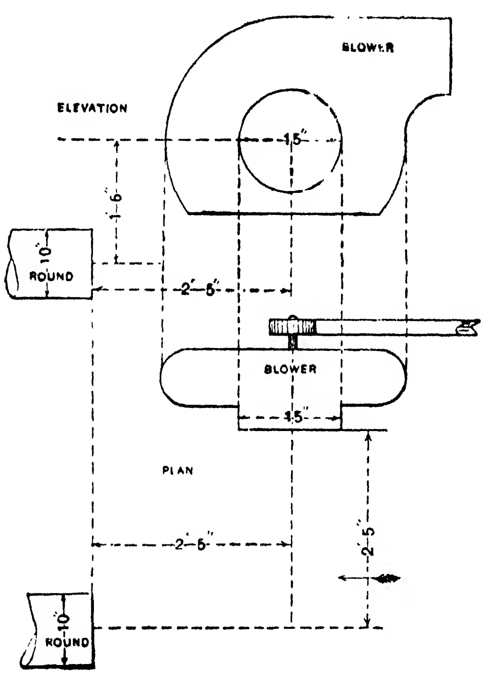


Fig. 225. A Sketch of the Problem

It is now necessary to obtain a proportional taper between I and E in plan. This is done by taking the distances of *m j*, *j i*, *i h* and *h f* and placing them on any vertical line, as *m' f'*, as shown by similar letters. From *m'* and *f'* draw horizontal lines, making *m'* I^1 and *f'* E^1 equal, respectively, to *m* I and *f* E in plan. Draw I^1 E^1, and from *j'*, *i'* and *h'* draw horizontal lines, intersecting I^1 E^1 at H^1, G^1 and F^1. Take the various distances, *j'* H^1, *i'* G^1 and *h'* F^1, and place them on the miter lines in plan, as shown by *j* H and *j* H°, *i* G and *i* G°, *h* F and *h* F°. Draw I H G F E and I° H° G° F° E°. Then will J D D° J° represent the plan of the elbow.

As the vertical distance from the center of the 10-inch pipe to the center of the 15-inch pipe is 18 inches, and as the elbow has four tapering sections in plan, then, on the line erected from A in plan, make m'' f'' equal to 18 inches. Divide the same into four equal spaces, as shown by h'', i'' and j''. From these divisions, draw horizontal lines which intersect by lines erected from similar letters in plan, representing the center points on the miter lines and resulting in the points of intersections f, h, i, j and m in elevation. The heavy dotted line traced through these points represents the center line of the elbow around which the tapering elbow must be constructed.

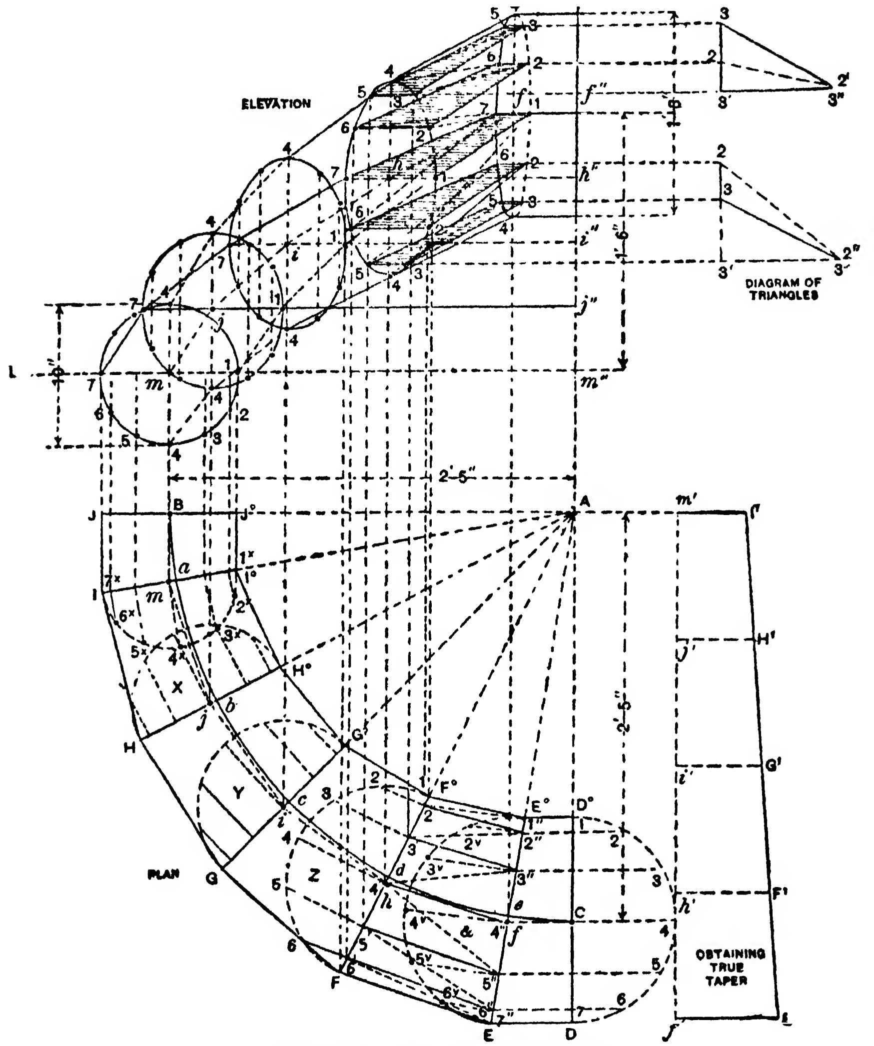


Fig. 226. Obtaining Miter Lines

To obtain this construction the elevation of the miter lines in plan must be projected as shown, after which each section (excepting the top and bottom) is developed by triangulation. With m in elevation as center, draw the 10-inch circle shown, and divide the lower half into equal spaces, shown from 1 to 7. From these points drop lines intersecting the miter line I I° in plan. At right angles to I I°, and from the intersections on same, draw lines as shown by 2^x 6^x, which are equal to similar lines 2 6 in the half circle m in elevation. 1^x 4^x 7^x is then the true section on I I° in plan. In similar manner, place the half section of the 15-inch pipe on D D° in plan and divide same into the same

number of spaces, as *m* in elevation, and obtain the true section on E E° in plan, as shown by 1″ 4″ 7″. At pleasure construct true sections on the miter lines H H°, G G° and F F°, which in this case have been assumed to be circles divided into the same number of spaces as in *m*. From the various intersections in X, Y and Z draw perpendiculars, cutting the miter lines as shown.

The method of obtaining the miter line in elevation on F F° in plan will explain the principles required for obtaining the other miter lines in elevation. From the intersections in Z lines are drawn perpendicular to F F°, intersecting same from 2′ to 6′. From these intersections vertical lines are projected into the elevation indefinitely, as shown. Through *h* in elevation, draw the horizontal line intersecting the vertical lines drawn from 1 and 7 in plan at 1 and 7 in elevation. Now, measuring from the line F F° in plan, take the various distances to points 2 to 6 and place them in elevation on similar lines measuring above and below the line 7 1 in *h*. A line traced through the points thus obtained, as shown by 1 4 7 4 1 in *h*, will be the miter line on F F° in plan.

Having obtained the miter lines, each section must be developed by triangulation. This is done by connecting similar points by solid lines and opposite points by dotted lines, as is shown in both plan and elevation for the upper section, *h f*; and requires no further explanation, as many examples are here presented.

PATTERN FOR A ROOM AIR DIFFUSER

In connection with the ventilating systems provided in New York schools, a diffuser of sheet metal is used at the air opening into the room wall to spread and direct the air, so far as possible, to get satisfactory circulation within the room and without giving rise to air drafts. The diffuser serves to direct the air upward more or less against the ceiling to spread the air in strata, which will descend more or less generally over the entire room area rather than in distinct currents. As the flues of a school building naturally come at different distances from the outside wall, the diffusers vary slightly in design to take account of this fact. The closer the air opening is to a corner of a room, the more is it desired that the air shall be directed away from the corner and to the center of the room, while a diffuser situated at the center of a wall would probably be designed to spread the air equally on both sides of the diffuser. As the pattern cutting of these diffusers is of more than passing interest, the following demonstration of the way that they are cut out has been obtained from a reader, who has had considerable of this work to do.

The accompanying drawings, Fig. 227, show the side elevation and the front elevation of one of the diffusers, in which it will be noted that it is calculated to divert more air toward the left than toward the right. The procedure in working up the pattern is as follows: The profile A B in the side elevation is divided into a convenient number of equal parts, in this case 10. From these points lines are extended horizontally until they intersect the miter line C D of the front elevation. Above the front elevation, in the usual way, is laid off the line X Y perpendicular to the horizontal lines, and on this is indicated the stretchout of the profile A B. Vertical lines from the points of intersection on the miter line C D

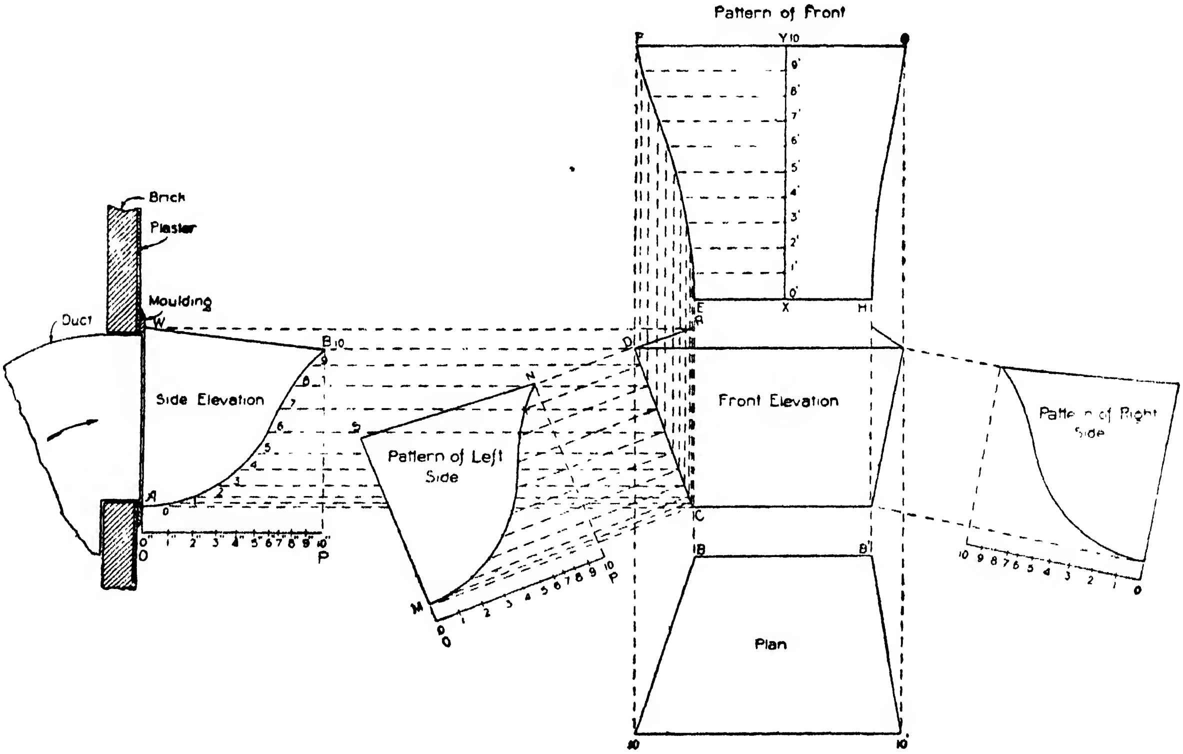


Fig. 227. Air Diffuser of Sheet Metal for Fresh-Air Inlet Openings of New York School Rooms

and horizontal lines drawn through the points 0′, 1′, 2′, etc., of the stretchout, intersect in a series of points, giving the curve of one side of the pattern of the front. This curve is E F. The outline H G is obtained in the same way, so that E F G H is the pattern of the front.

The pattern of each side is obtained in an equally simple manner. A horizontal line O P is drawn underneath the side elevation. Lines are projected from the points of division on the profile, obtaining the points 0″, 1″, 2″, 3″, etc. Perpendicular to the miter line C D in the elevation, lines are drawn from the points of intersection on the miter line, these lines being projected indefinitely to the

left of C D as indicated. Parallel with these lines and at some convenient point is laid off the line O P with the exact location of the points 0″, 1″, 2″, 3″, etc. Lines projected perpendicular to the new location of O P intersect corresponding lines perpendicular to C D, and a curve drawn through points of intersection gives the true curve of the miter line of the left side of the pattern.

The point S is not obtained as might first be assumed from the drawing by continuing line D N until it is intersected by the line O S. Instead, the true length of W B of the side elevation is obtained. An arc is then described about N as a center, with a radius equal to this true distance, and where this arc is intersected by another arc described about the point M as a center and with a radius equal to the distance C R of the front elevation, is determined the position of S.

In order to get the true length of the line W B, a plan is drawn below the front elevation, with the two parallel lines B B′ and 10 10′ spaced apart equal to the distance W B of the side elevation. Lines projecting vertically downward from C and D locate the points B and 10 and then B 10 is the true length of W B. The arc described about the center N therefore has a radius equal to B 10. The true length of the other radius is that given directly by C R. The intersection of the two arcs determines the location of S, and S M N is therefore the pattern for the left side. The pattern for the right side is obtained in a similar way.

PATTERNS FOR A BRANCH—INTERSECTING SCALENE CONE AND TRANSITION PIECE

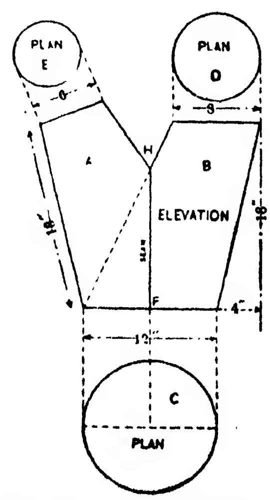


Fig. 228 Sketch of the Problem

This article deals with the method of cutting the patterns for the branch reproduced in Fig. 228, which portrays the conditions imposed—conditions that are of frequent occurrence in the trade. As will be seen, the problem involves a transition piece, A, intersecting the scalene cone B. The seam is to come on a vertical line central over the center in plan; and it is to be understood that cylindrical collars would be attached at the 6-in., 8-in. and 12-in. openings, but as they involve no especial principles of pattern cutting, they were not detailed in this figure.

Fig. 229 is an enlarged view. Extend G F and A E until they intersect at X. From X, and from A, Y and H, the center points of B C, E F and A G, drop lines inter-

secting Z &. Divide the base in plan, I J K L, into equal spaces, as shown by 1 to 7, and from these points draw radial lines to the apex &, as shown. The line of joint is shown by D H in elevation, and as the point H comes over the point 4 in plan, to obtain a plan of the joint line erect at right angles to I & and from points 1, 2 and 3, lines intersecting A G at A, *b* and *c*. From these points draw lines to the apex X, cutting H D at $1'$, $2'$, $3'$. As the joint, or rather seam, D H is a perpendicular line in elevation it will consequently show a straight line in plan, L J, and will intersect radial lines in plan at $1''$, $2''$, $3''$ and $4''$.

Trace the ellipse D^1 E^1 C^1 Z, which is the plan of B C in elevation. Draw D^1 L and C^1 J. Then will D^1 L J C^1 Z be the plan of the irregular transition piece, shown in elevation by A B C D H. L J P K^1 O represents the plan of the scalene cone, shown in elevation by H G F E D.

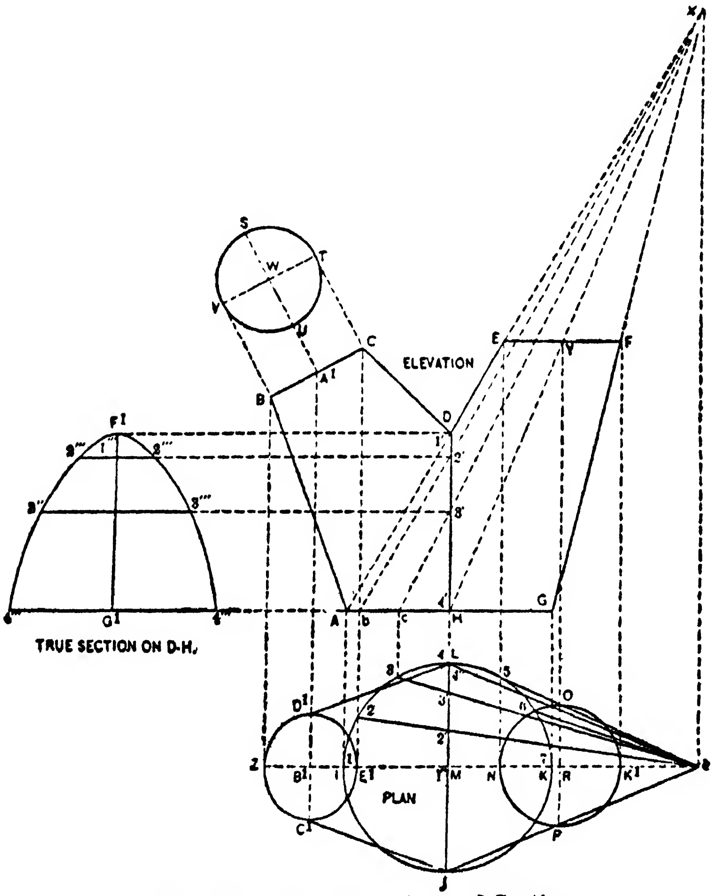


Fig. 229. Plan, Elevation and Section

From the intersections $1'$, $2'$, $3'$, $4'$ on D H of the elevation draw lines parallel to G A, extending them to the left, as shown, intersecting the vertical line F^1 G^1, onto which the true section on D H is to be constructed, as follows: Measuring in every instance from the center line Z & in plan, take the distances in the dividers to points $2''$, $3''$ and $4''$ and place them on the horizontal lines having similar numbers, measuring right and left from F^1 G^1, as shown by intersections $1'''$, $2'''$, $3'''$ and $4'''$ on either side. Trace a line through the points thus obtained and $4'''$ $1'''$ $4'''$ will be the section D H.

For the pattern for the scalene cone proceed as follows: Let X E A G F of Fig. 230 be a reproduction of similar letters and figures in elevation in Fig. 229, and let the half plan I J K be a reproduction of similar half plan in Fig. 229, with the divisions similar to those on I L K. Then with & in Fig. 230 in plan as

center and radii equal to & 1, & 2, & 3, & 4, etc., draw arcs intersecting the line I K, as shown. At right angles to I K and from the intersections on same draw lines intersecting A G, as shown by 1′ to 7′. From the intersections on A G draw lines to the apex X, intersecting the top of the cone E F, as shown by points 1 to 7.

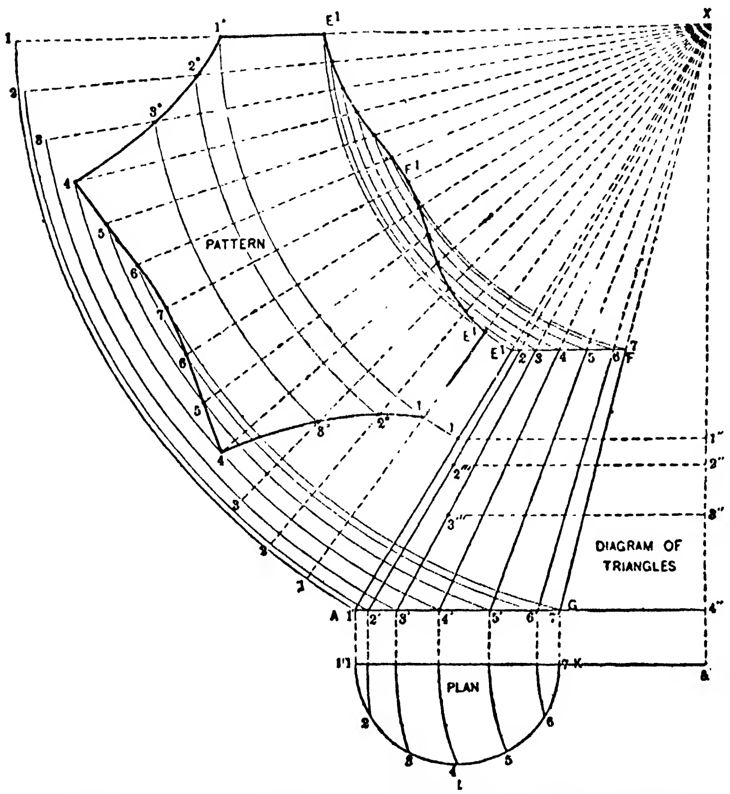


Fig. 230. Plan and Elevation, and Pattern for Scalene Cone

Extend A G to 4″. Now take the various hights in elevation in Fig. 229, as 4′, 3′, 2′ and 1′ on D H, and place them on & X in Fig. 230, starting at 4″, obtaining the points 3″, 2″ and 1″. At right angles to X & and from 1″, 2″, 3″ and 4″ draw lines intersecting hypotenuses of triangles having similar numbers at 1‴, 2‴, 3‴ and 4′. Now, with X as center and radii equal to X 1′, X 2′, X 3′, etc., draw arcs indefinitely, as shown. Set the dividers equal to the spaces into which the plan is divided, and, setting one leg of the dividers upon the arc 1, step from one arc to the other, placing the division 2 of the plan on the arc 2 in the pattern, 3 of the plan on the arc 3 in the pattern, until all of the divisions necessary to complete the full pattern are obtained, as shown by the small figures 1 to 7 and 7 to 1. From these figures draw lines to the apex X. Now, with X as center and radii equal to X 1‴, X 2‴ and X 3‴ draw arcs intersecting radial lines in pattern of similar numbers, as shown by 1°, 2° and 3° on either side in the pattern. Finally, with X as center and radii equal to X 1, X 2, X 3, etc., on E F draw arcs intersecting radial lines of similar numbers in the pattern, as shown. Trace a line through points of intersections thus obtained and E^1 F^1 E^1 1° 4 4 1 will be the required pattern for the scalene cone.

The patterns for A B C D H in Fig. 229 will be developed by triangulation; therefore in Fig. 231 let 1 14 8 7 22 be a reproduction of A B C D H in Fig.

229. Take a tracing of the half section V S T and place it as shown by 14 11 8 in Fig. 231. In similar manner take a tracing of the quarter circle I M J in plan in Fig. 229, with the divisions equal to 1 L thereon, and place it as shown by 1 22 4 in Fig. 231. Finally take a tracing of the half section F^1 G^1 $4'''$ in Fig. 229, with the points of intersections on same, and place it as shown in Fig. 231 by 7 22 4′.

At right angles to 1 22 and from 2 and 3 draw lines intersecting the line 1 22 at 24 and 23. In the same manner, at right angles to 7 22 and from points 5 and 6 draw lines intersecting the line 7 22 at points 21 and 20. As the two

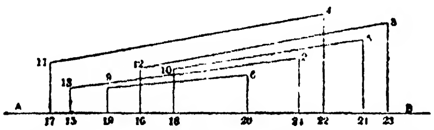


Fig. 232. Diagram of Sections on Solid Lines in Fig. 231

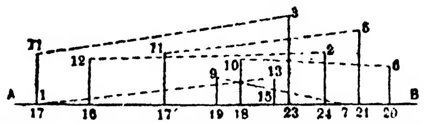


Fig. 233. Diagram of Sections on Dotted Lines in Fig. 231

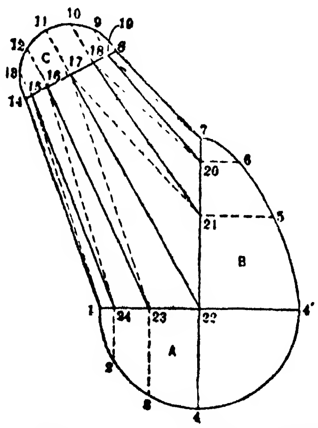


Fig. 231. Diagram for Obtaining Measurements for Sections

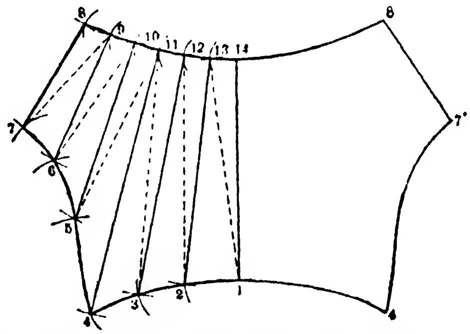


Fig. 234. Pattern Shape for Transition Piece

sections A and B have a total of six divisions, then divide the profile or section C into six spaces, as shown by the small figures 8 to 14. At right angles to 8 14 and from the figures draw lines intersecting 8 14 at points 15 19. Draw solid and dotted lines in 14 8 7 1, as shown. Then will these lines represent the bases, the section of which will be constructed, having altitudes equal to the lines drawn in profiles A, B and C.

For the sections on solid lines draw any horizontal line, as A B in Fig. 232, upon which place the various lengths of the solid lines in Fig. 231, as shown by having similar figures in Fig. 232. For example, take the distance 17 22 in Fig. 231 and place it as shown by the line 17 22 on A B in Fig. 232. At right angles to 17 22 and from points 17 and 22 erect lines, making 17 11 and 22 4 equal to 17 11 and 22 4 respectively in Fig. 231. Draw a line from 4 to 11 in

Fig. 232, which will represent the actual distance on the finished article on the line 17 22 in Fig. 231.

Proceed in similar manner for all sections on solid lines in Fig. 321, similar parts corresponding to similar figures in Fig. 232. Also proceed in similar manner for diagrams of sections on dotted lines, as shown in Fig. 233 upon the line A B.

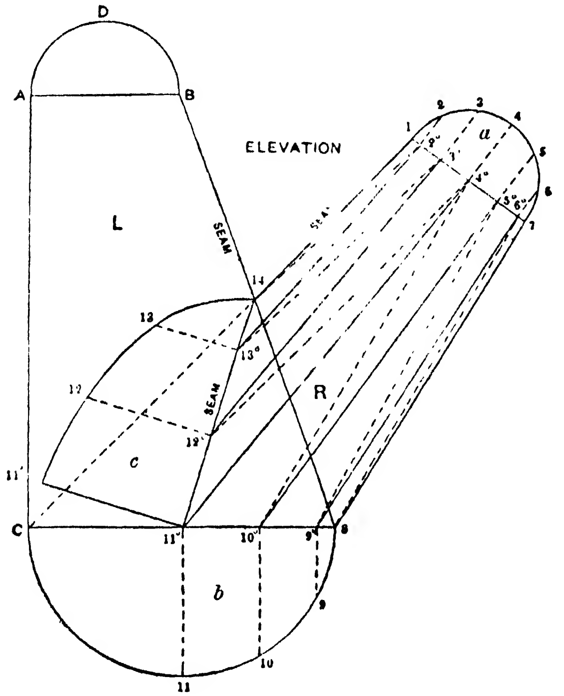


Fig. 235. Elevation and Sections of Branch with Same Diameter

For the pattern draw any vertical line, as 1 13 in Fig. 234, equal to 1 14 of Fig. 231. Now with 14 of Fig. 234 as center and 14 13 of Fig. 231 as radius describe the arc at 13. Then, with radius equal to 1 13 of Fig. 233 and 1 of Fig. 234 as center describe an arc intersecting the previous arc at 13. Next, with 1 2 of Fig. 231 as radius and 1 of Fig. 234 as center describe the arc 2. Then, with 13 2 of Fig. 232 as radius and 13 of Fig. 234 as center describe an arc intersecting the previous arc at the point 2. Proceed in similar manner until all the divisions necessary to complete the pattern have been placed, as shown by similar figures in Fig. 234.

Trace a line through the points obtained, as shown by 14 8 7 4 1, which completes one half the pattern. The other half can be traced opposite.

Should both pipes of the branch be of the same diameter the elevation would be drawn as shown in Fig. 235. After obtaining the true section on the seam line by the aforesaid process the developing of the patterns would be as described for Figs. 229 and 234

ANOTHER METHOD FOR A PATTERN FOR THREE-WAY BRANCH

One of the problems submitted outlined a method of obtaining the pattern for a three-way branch, like that shown on page 88, affording a simple solution for same. It is conditional on having the branches at 45 degrees with each other, but as this is usual in work of the kind the solution is altogether practical.

As will be seen in Fig. 236, the branches lie all in the same plane, and are all of the same cross-sectional area. The feature of the solution is that only one layout is required and one pattern suffices. Geometrically, the three-way branch as here outlined, comprises the intersection of parts of three right cones. The cones being identical, the view of the miter line between joining cones is a straight line, as shown in the cut.

The method of obtaining the pattern is pretty clearly indicated. Dotted lines are drawn as usual between ends of the elements of the cone surface and the elements themselves are left in full lines. The true lengths of lines 1 to 7 inclusive are obtainable directly from the conical surface by the use of the semicircles as

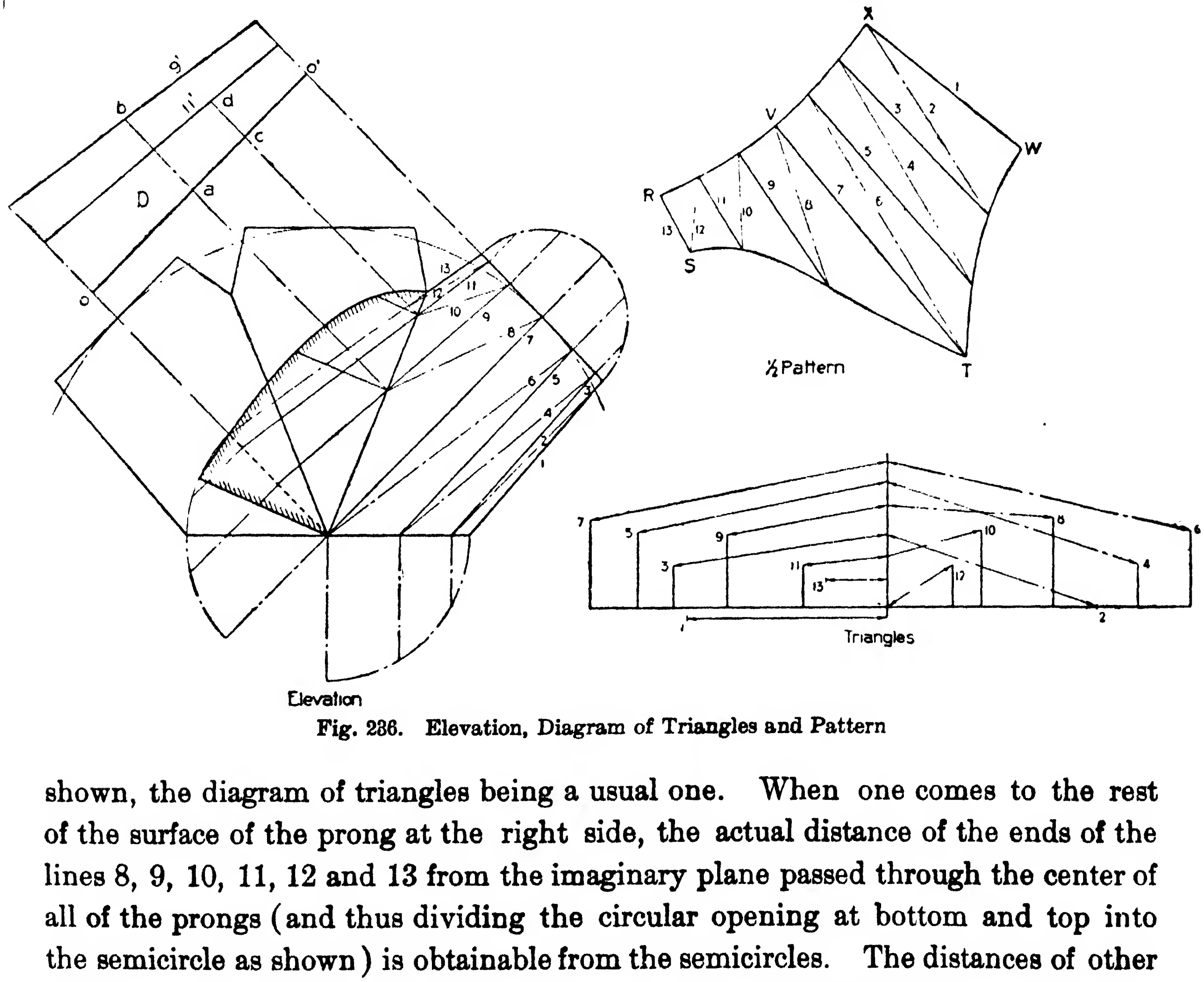


Fig. 236. Elevation, Diagram of Triangles and Pattern

shown, the diagram of triangles being a usual one. When one comes to the rest of the surface of the prong at the right side, the actual distance of the ends of the lines 8, 9, 10, 11, 12 and 13 from the imaginary plane passed through the center of all of the prongs (and thus dividing the circular opening at bottom and top into the semicircle as shown) is obtainable from the semicircles. The distances of other points on this conical surface from this same plane are derived by remembering that they lie in definite elements of the surface of the right cone.

Other elements of the right prong surface are continued to a dotted line representing the base of the cone, and at that point a quarter circle is drawn in order to

learn the distance of the ends of the elements from the plane already mentioned. To the left of the cone has been drawn the line 0 0′, parallel to the axis of the right cone. From the semicircles at the opposite end of elements 9 and 11 distances have been laid off perpendicularly to the line 0 0′, and the resultant inclined lines 9′ and 11′ at D show the distance of any point in either of these lines from the lines 0 0′, or, in other words, the distance from the plane passed through the center of the right cone.

The application of this simple arrangement is as follows: To get the actual length of the line 8, the horizontal distance is laid off as usual in the diagram of triangles. The distance of one end of the line 8 from the imaginary plane is obtainable from the upper semicircle. The distance of the other extremity of the line 8 from that same plane is obtainable from the diagram D. As this extremity of 8 lies on the element 9, the distance of the extremity of line 8 from the plane is equal to the distance *a b* of the diagram D. Similarly, the distances from the plane mentioned for determining the actual length of the line 9 are obtainable in one case from the small semicircle and in the other case by the distance *a b*. Similarly, the line 10 has one extremity in the element 11, and this distance is equal to *c d* of diagram D.

The one half pattern shown is obtained in the usual way by taking the equal distances from the semicircles and also the actual length of the lines as shown in the diagram of triangles, alternating with full and dotted lines. The entire half pattern R S T W X is a half pattern for each of the outer prongs. The part of the pattern R S T V is a quarter pattern of the central prong.

PATTERNS FOR INTERSECTING PIPES

The following is the method of laying out the patterns for a round smoke pipe that joins an upright pipe having flat sides and round ends. The round pipe inclines to the vertical pipe at about 45 degrees, both vertically and horizontally.

In the accompanying illustration, Fig. 237, A B in plan represents the oblong pipe, while C D shows the round pipe intersecting the oblong pipe at an angle of 45 degrees. A^1 B^1 shows the elevation of the oblong pipe intersected by the round pipe C^1 D^1, also at an angle of 45 degrees. The line of intersection in the elevation has been omitted, as it is not required in the development of the pattern. If the intersections were required for the purpose of making a finished drawing this could be done by dropping lines from the intersections in plan into

the elevation, and intersecting same by lines drawn from the intersections in the profile *b″* from similar numbers, parallel to the lines of the pipe.

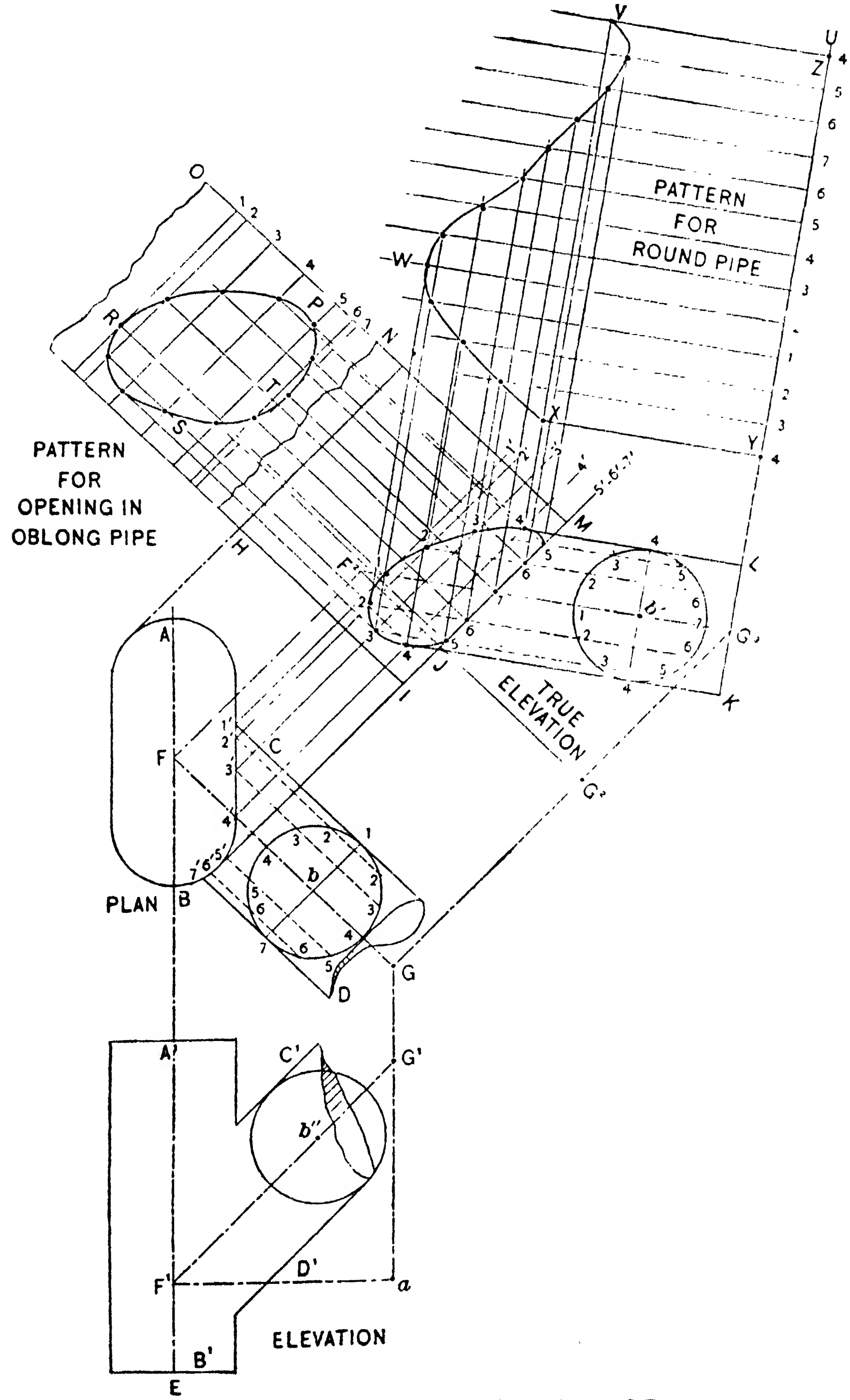


Fig. 237. Plan Elevation, True Elevation and Patterns

The first step necessary in the development of the patterns is to obtain a true elevation, for which proceed as follows: Draw a center line through the elevation

and plan of the oblong pipe, as shown by A E. In similar manner draw a center line through the round pipe C D in plan, as shown by F G, intersecting the line A E at F. Also draw a line through the center of the round pipe in elevation, as shown by G^1 F^1, intersecting the center line A E at F^1. At pleasure establish any point on the center line F G in plan, as G. From G drop a perpendicular line intersecting the center line F^1 G^1 in elevation at G^1, extending the line G G^1 until it intersects the line drawn from the point F^1 at right angles to A^1 E at *a*. Then will these points form the basis of measurements for obtaining the true elevation.

Now parallel to F G in plan draw the line F^2 G^2, equal in length to F G. At right angles to F^2 G^2 draw the line G^2 G^3, equal to *a* G^1 in elevation. Draw a line from G^3 to F^2, which will represent the true length of the center line of the round pipe on F G in plan. At right angles to F^2 G^3 draw the line L K, equal to the diameter of the round pipe, and describe the circle *b′*, which divide into equal spaces, as shown. In similar manner describe the circle *b* in plan view, which divide into the same number of spaces, as shown from 1 to 7 to 1. Parallel to the lines of the pipe draw lines intersecting the oblong pipe at points 1′ to 7′. Then at right angles to F G and from points 1′ to 7′ draw lines indefinitely, as shown, which intersect with lines drawn parallel to F^2 G^3 from similar numbered intersections in the circle *b′*, as shown by points in the miter line 1 to 7 to 1. Trace a line through points thus obtained, which will give the true points of intersections between the round and oblong pipes at an angle of 45 degrees, both vertically and horizontally.

As confusion is apt to arise in numbering the points in circles *b* and *b′* an explanation may not be out of place. Assume that 1 7 in plan of the circle *b* is a pivot, and the circle is turned so that one point 4 comes above and the other point 4 below, then for this reason should the points 4 and 4 in circle *b′* come below and above respectively, as shown.

From the extreme point of the oblong in plan, as A, erect the line to the true elevation, as shown. Then will H I J K L M N be the true elevation of the round and oblong pipes. For the pattern for the opening to be cut into the oblong pipe extend the line M N, as shown by M O, upon which place the stretchout of the intersections on the oblong pipe in plan 1′ to 7′, as shown by the small figures 1 to 7 on N O. From these small figures and at right angles to O N draw lines, as shown, which intersect by lines drawn from similar numbered intersections in the miter line M F^2 J at right angles to M I. Trace a line through the points thus obtained, then will P R S T be the pattern shape for the opening in the oblong pipe.

For the pattern for the round pipe draw any line at right angles to J K, as Y U, upon which place the stretchout of the circle *b*′, as shown by 4 to 1 to 4 to 7 to 4 on Y U, thus bringing the seam on the line 4 L in true elevation. At right angles to Y U and from the small figures draw lines indefinitely, which intersect by lines drawn at right angles to M L in true elevation from similar numbers in the miter line M F^2 J. Trace a line through these points of intersections thus obtained in pattern, as shown by V W X. Then will V W X Y Z be the pattern for the round pipe.

TAPERING ELBOW IN SQUARE PIPE

This is an exemplification of how to lay out an elbow, tapering from 10 inches square to 4 inches square. In Fig. 238, let 1 2 3 4 5 6 be the side elevation of the elbow, 1 2 3 forming a right angle. Let 1′ 6′ 6″ 1″ be the section in plan on the line 1 6 in elevation, and A B C D the section on 3 4. Through this section draw the center line E F. Draw J H, the center line in plan.

As the elbow tapers it will be necessary to obtain the true widths at the points 2 and 5 in elevation, as follows: Upon the line H J in plan lay off the stretchout of 1 2 3 in elevation, as shown by 1°, 2° and 3° in plan. At right angles to H J, and through these small figures, draw 1 1, 2 2 and 3 3, making 1 1° equal to half 1′ 1″ in plan, and 3 3° to A E or E B in section. On both sides, from the points 3 draw lines to 1, intersecting 2 2. Then 1 2 3 3 2 1 will be the pattern for the top of the elbow, shown by 1 2 3 in elevation; 2 2 in the pattern is the true width in plan on the point 2 in elevation.

In similar manner take the stretchout of 6 5 4 in elevation and place it on the line H J in plan, as shown by 6°, 5° and 4°. Proceed as before, obtaining 4 5 6 6 5 4, the pattern for the bottom of the elbow shown by 4 5 6 in elevation; 5 5 in pattern is the true width on 5 in elevation.

To draw the plan of the elbow proceed as follows: Parallel to H J in plan, and from points 2 and 2 in pattern, draw lines intersecting 1′ 1″ at 2′ 2″. This gives the width in plan of point 2 of elevation. At right angles to 2 3 in elevation, and from points 3, 4 and 5, drop lines into the plan indefinitely, which intersect lines drawn parallel to H J from points having similar numbers on the two patterns, as shown by intersections 3′ 4′, 3″ 4″, 5′ and 5″ in the plan. Draw lines from 6′ to 5′ to 2′ to 3′ 4′ to 5′; also from 6″ to 5″ to 2″ to 3″ 4″ to 5″, which will be the plan of the elbow.

Before obtaining the patterns for the sides of the lower and upper arms it will be necessary to construct three triangles, for which proceed as follows: Draw dotted lines in elevation from 3 to 5 and from 5 to 1. These are represented in plan by $3'\ 5'$ and $5'\ 1'$. At right angles to 2 1 in elevation, and from points 2, 5 and 1, draw lines to the left indefinitely, as shown. Now take the distance of $5\ 1'$ in plan and place it on 1 K, as shown by $5^x\ 1^x$. From 5^x erect a line intersecting 5 L

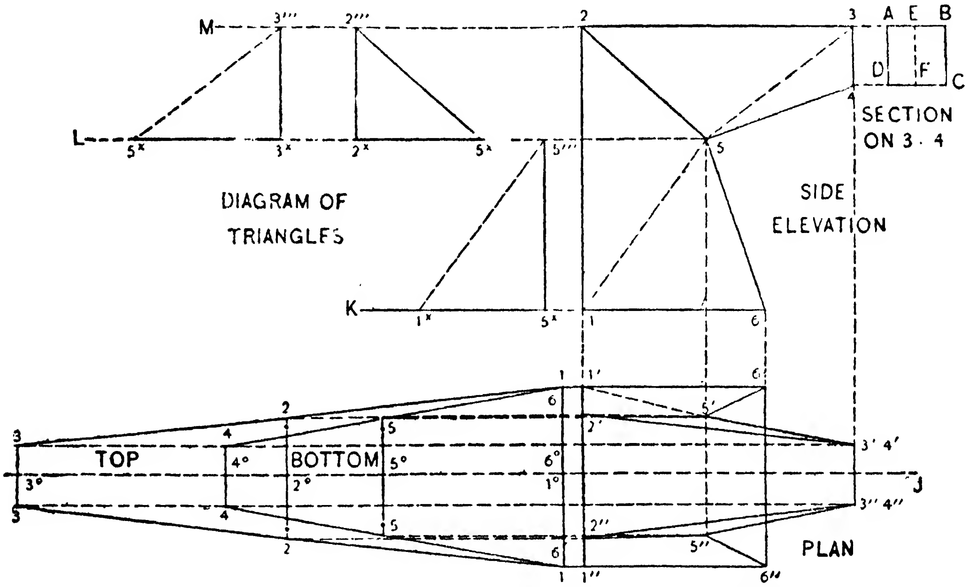


Fig. 238. Plan, Elevation and Patterns for Top and Bottom

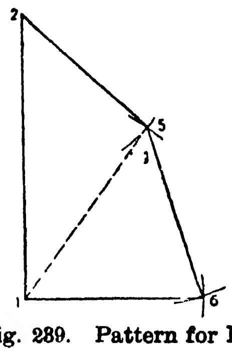


Fig. 239. Pattern for Lower Side

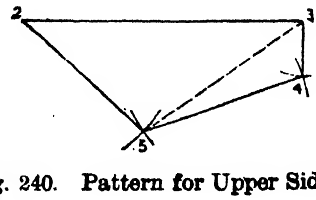


Fig. 240. Pattern for Upper Side

at $5'''$. Draw $5'''\ 1^x$, which is the true distance on 5 1 in elevation. In similar manner take the distances in plan $2'\ 5'$ and $5'\ 3'$ and place them on 5 L, as shown by $2^x\ 5^x$ and $5^x\ 3^x$. From 3^x and 2^x erect lines intersecting 2 M at $3'''$ and $2'''$. Then will $2'''\ 5^x$ and $3'''\ 5^x$ be the actual distances on the finished elbow when measured on the lines 2 5 and 3 5 in elevation.

For the pattern for 1 2 5 6 draw any line, as 1 2 in Fig. 239, equal to 1 2 in the patterns for top in Fig. 238. Then with $1^x\ 5'''$ in the diagram of triangles

as radius, and 1 in Fig. 239 as center, describe the arc 5, which intersect with an arc struck from 2 as center, with a radius equal to 2‴ 5ˣ in the diagram of triangles in Fig. 238. With 5 6 in the pattern for bottom as radius, and with 5 in Fig. 239 as center, describe the arc 6. With 1 as center, and with 1 6 in elevation in Fig. 238 as radius, intersect the arc 6 in Fig. 239, as shown. Trace a line through points thus obtained. Then will 1 2 5 6 be the desired pattern.

For the pattern for the upper side of the elbow draw 2 3 in Fig. 240 equal to 2 3 in the pattern for top in Fig. 238. Then with 2‴ 5ˣ in the diagram of triangles as radius, and with 2 in Fig. 240 as center, describe the arc 5, which intersect by an arc struck from 3 as center, with a radius equal to 3‴ 5ˣ in the diagram

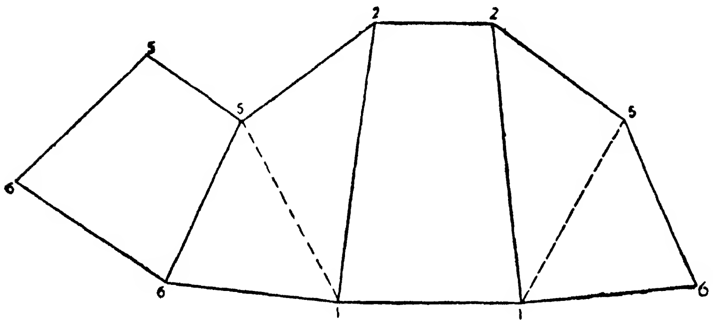


Fig. 241. Pattern for Lower Arm in One Piece

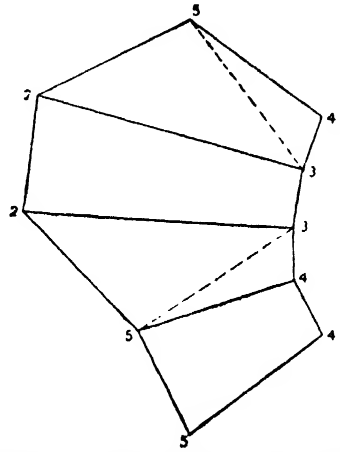


Fig. 242. Pattern for Upper Arm in One Piece

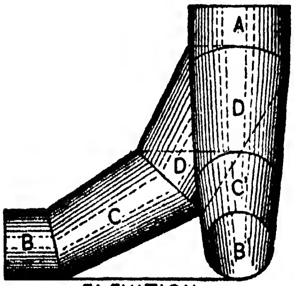
of triangles in Fig. 238. Now using 3 4 in elevation as radius, and 3 in Fig. 240 as center, describe the arc 4, which intersect by an arc struck from 5 as center, with a radius equal to 5 4 in the pattern for bottom in Fig. 238. A line traced through these points, as shown by 2 3 4 5, will be the desired pattern.

If it is desired to make the lower and upper arms each complete in one pattern, this can be done as shown in Figs. 241 and 242. In Fig. 241, 1 2 2 1 is a tracing of the top pattern 1 2 2 1 in Fig. 238, while 1 2 5 6 on either side in Fig. 241 is a tracing of 1 2 5 6 in Fig. 239, and 5 6 6 5 in Fig. 241 a tracing of 5 6 6 5 in the pattern for bottom in Fig. 238. Fig. 242 is a similar combination of the patterns of the sides for the upper arm of the elbow.

PATTERNS FOR INTERSECTING TAPERING ELBOWS

This problem is to find the patterns for two similar, pieced tapering elbows that intersect. The elbow has three openings as shown in Fig. 243. The two

arms of the elbow are symmetrical, so it will be necessary to construct the elevation of but one arm, in which the true taper, miter lines and true sections are obtained.



ELEVATION
Fig. 243. Sketch of the Problem

From A, in Fig. 244, with radius equal to the curve made by the center line of one branch, describe the arc D E. As the elbow has four pieces, divide D E into three equal parts by *a* and *b*. Bisect D *a*, obtaining the joint *c*. Starting from *c*, set the dividers equal to D *a* and step off to the points *d* and *e*. From A draw lines through D, *c*, *d*, *e* and E. Perpendicular to A D draw D *h*. From *d* and *e*, on the miter lines M N and G H, lay off distances equal to *c h*, locating points *i* and *f*. Draw *h i*, *i f* and *f* E, the center lines of the elbow pieces. Describe the half sections U and P of the large and small ends, from D and E as centers. From I and B draw lines parallel to D *h*, intersecting J K. In similar manner, from C and F draw lines parallel to E *f*, intersecting H G. To obtain a proportionate taper between J K and G H, take half of G H and place it on J K, from *h* to *j*. Bisect *j* K, obtaining *n*. Take the distance *h n* and place it on M N, from *i* to N and *i* to M. Draw J M, M G, K N and N H. Then will I F C B be the desired elevation.

To obtain the true sections on J K, M N and G H, divide U into equal parts, as shown by 1 to 5. From these draw lines parallel to D *h*, intersecting J K from 1‴ to 5‴. From these points, perpendicular to J K, draw the lines 2‴ 2, 3‴ 3 and 4‴ 4, equal to the hights of 2, 3 and 4 in U. Draw the semi-ellipse T, the true half section on J K. In similar manner obtain half section R. For the half section on M N, draw from *i*, *i o*, perpendicular to *h i*. Then perpendicular to M N draw *i* 3, equal to *i o*. Through M, 3 and N draw the semiellipse S. Divide this into four equal parts, and from these points drop lines intersecting M N at 1″ to 5″.

It is now necessary to obtain a plan of the elbow, showing the intersection between the two arms and the horizontal projections of the miter lines. To avoid confusion of lines, a tracing of the elbow is taken and placed in Fig. 245. Draw the horizontal line O P. From D erect D 5°. From 5° describe the circle 1 3 5 3, representing the section on I B. Divide U into the same number of parts as contained in U in Fig. 244, as shown by similar figures.

Take a tracing of the half section S, in Fig. 244, and place it as shown by S in plan in Fig. 245, the center *i* and the points 1 and 5 being on O P. Parallel to O P, from the small figures in S, draw lines, partly shown, intersecting lines drawn at right angles to O P from similarly numbered intersections on M N.

Trace a line through points thus obtained; then will S^1 be the horizontal projection of section on M N.

From F, G and H erect lines intersecting O P at F^1, G^1 and H^1. Take the distance of E F and place it as shown from F^1 to E^1 and F^1 to E^2. From E^1 and E^2 draw horizontal lines, intersecting the line erected from f in elevation at f' and f'' in plan. Trace an ellipse through f', G^1, f'', H^1 and draw f'' 3 3 and f' 3 3. Then will E^2 3 5 3 E^1 be the plan of one arm of the elbow.

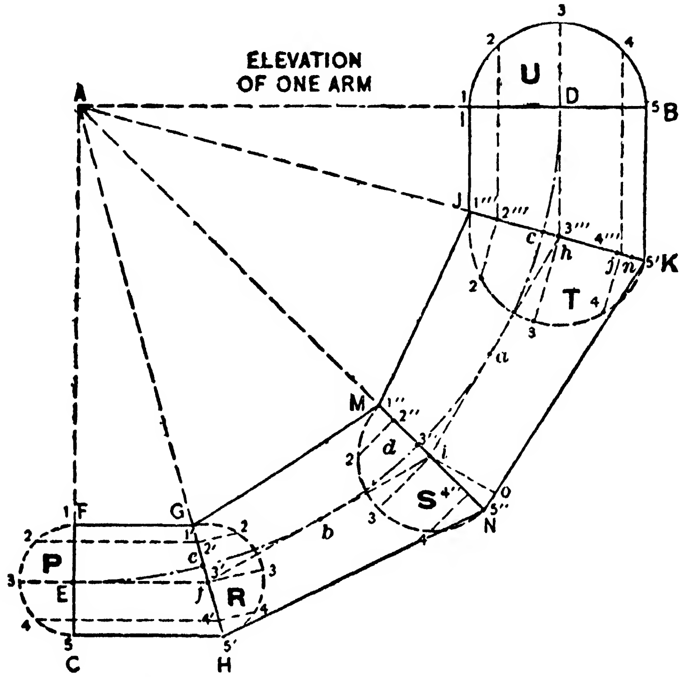


Fig. 244. Elevation of One Arm and Sections

Through the point 5° in plan, at an angle of 45 degrees, half the angle at which the arms meet in plan, draw the projection of the line of joint R T.

The patterns for I B K J and F G H C are obtained by the usual method employed for finding elbow patterns in round pipe. The half patterns are developed in Fig. 245 and are shown by U^1 V X W and Y G^1 H^1 Z.

From the various intersections on J K and M N draw solid lines from 2″ to 2‴, 3″ to 3‴ and 4″ to 4‴, and dotted lines from 2″ to 1‴, 3″ to 2‴, 4″ to 3‴ and 5″ to 4‴. In similar manner connect the same numbers in U and S^1. The joint line, R T, in plan cuts 5 5 at 5°, 5 4 at *b*, 4 4 at 4°, 4 3 at *a* and 3 3 at 3°, and the section U at 2 and 4. From these various points of intersection drop lines intersecting similarly numbered solid and dotted lines in elevation, as shown respectively by 5°, *b*, 4°, *a*, 3°, 2° 2°, 4° and 4°. Trace a line

through points thus obtained, which will be the line of joint in elevation. This has been shaded in Fig. 245 to clearly show the plane of the miter line.

The next step is to obtain measurements for the diagram of sections on the various solid and dotted lines. In Fig. 246, 1 5 5″ 1″ is a reproduction of J K N M in Fig. 245, and T and S of T and S in Fig. 244. Then will the solid and dotted lines in 1 5 5″ 1″ represent the bases of the sections the altitudes of which are equal to the various hights in T and S. For the sections on the solid lines proceed as is shown in Fig. 247. For example, take the distance of $4'$ 4^v, in Fig. 246, and place it on the horizontal line in Fig. 247, as shown. From $4'$ and 4^v erect lines $4'$ 4 and 4^v 4″, equal to $4'$ 4 in T and 4^v 4″ in S, in Fig. 246. Draw 4 4″ in Fig. 247, which represents the true length on $4'$ 4^v in Fig. 246. In this manner the other sections on the solid lines are obtained. The same principle is used in obtaining the sections on the dotted lines, as shown in Fig. 248.

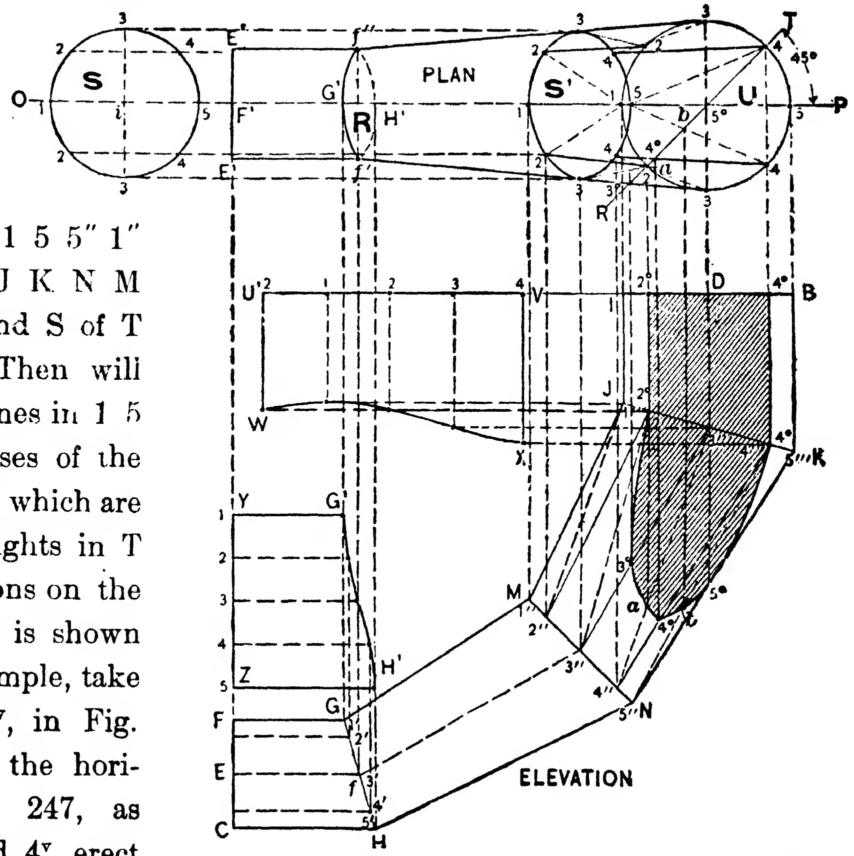


Fig. 245. Plan and Elevation and Patterns for End Pieces

For the pattern, draw 5 5″, in Fig. 249, equal to 5 5″ in Fig. 246. Then, by the usual rules of triangulation, develop the half pattern, as shown by 5 1 1″ 5″ in Fig. 249. Opposite it trace the other half, shown by 5 1^v 1^x 5″. The full pattern is thus obtained, on which must be located the miter line. Take the various distances on the solid lines in Fig. 246, as $3'$ to 3° and $4'$ to 4°, and place them on the horizontal line in Fig. 247, as shown from $3'$ to 3° and $4'$ to 4°. From 3° and 4° erect lines intersecting 3 3″ and 4 4″ at 3^x and 4^x respectively. Take the distances 3 to 3^x and 4 to 4^x and place them on similar numbered solid lines in the pattern in Fig. 249, as shown from 3 to 3° and 4 to 4°. Now take the distances in Fig. 246, on the dotted lines, from $3'$ to *a* and

from 4′ to b, and determine their true lengths in Fig. 248. Take these true distances, placing them on similarly numbered dotted lines in pattern, thus locating a and b in Fig. 249. Take the distance from 5 to 5° in Fig. 246 and place it from 5 to 5° in Fig. 249.

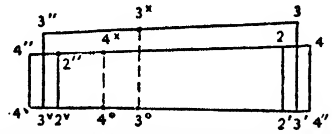


Fig. 247. Sections on Solid Lines

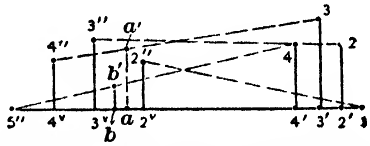


Fig. 248. Sections on Dotted Lines

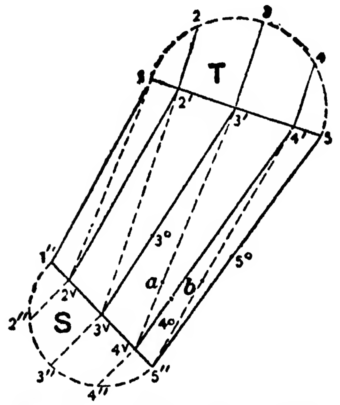


Fig. 246. Diagram for Obtaining Measurements for Sections

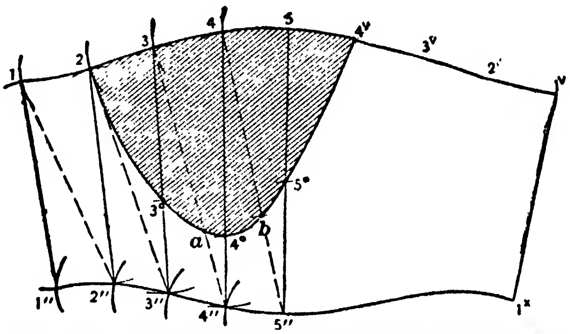


Fig. 249. The Pattern for J K N M in Fig. 245

As the line of joint R T in plan, in Fig. 245, passes through point 2 and 4, start from 2 in Fig. 249 and trace a line through 2, 3°, a, 4°, b, 5°, 4^v. Then will 1 2 4° 4^v 1^v 1^x 1″ be the full pattern for J K N M in Fig. 245 for each arm. In the same manner obtain the pattern by triangulation for the piece M N H G, using the sections S and R in Fig. 244. Laps must be allowed for seaming or riveting.

PATTERNS FOR SHIP VENTILATING COWL

An interesting article on patterns for a ship ventilating cowl is as follows:

What is termed a standard cowl is explained in connection with Fig. 250. Start by erecting a line perpendicular to the base line from point A, extending it indefinitely. The diameter of the base, assuming it to be 14 in., is marked off to the right of this line, establishing point B. The radius of the throat is next determined by taking one-fourth the diameter of the base, or 3½ in., which is marked off on the base line to the right from point B to point C. From C erect a line with an inclination to the right of 82 degrees from the base line. With one leg of the dividers at C and with radius 3½ in., or B C, draw the throat line until it intersects the inclined line at point D. The mouth of the cowl is laid off

on the inclined line from point D, and is found by taking twice the diameter of the base, which gives 28 in. With this distance from point D establish point E. Draw the radius of the back, which is taken as one and one-half times the diameter of the base, in this case 21 in. With this radius and one leg of the dividers at point E, the other should be so located that when the arc defining the back is drawn the vertical line, erected from the base line at point A, will be tangent to it, completing the outline of the cowl. This method, in the form of a formula, is assuming B to represent base; T, throat; M, mouth, and R, radius of back, would read: B = 14 in.; T = ¼ B, or 3½ in.; M = 2 B, or 28 in.; R = 1½ B, or 21 in.

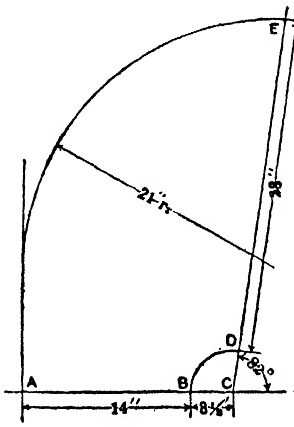


Fig. 250. Elevation in Outline

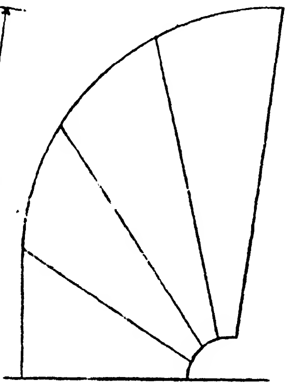


Fig. 251. Division of Cowl

The back and throat lines are now divided into four equal parts and these points connected by lines, as in Fig. 251, thus dividing the surface into four sections, each section of which is developed by triangulation. The development of one section will serve to show the method employed in all.

To avoid confusion of lines transfer the bottom section, as in Fig. 252, where A G and 1 7 represent the section. Bisect A G and 1 7, and with these points as centers draw a semicircle on each side, which will represent a half plan of each end of the section. Divide these semicircles into a convenient number of equal parts, in this case six. Project these points to the elevation by lines in the semicircle A G. Letter these lines A, B, C, etc. To avoid confusion in the semicircle 1 7, number the lines 1, 2, 3, etc. Divide the elevation into triangles by connecting 1 and B, B and 2, 2 and C, C and 3, 3 and D, and so on, until all the points have been connected. Beginning with the line 1 A, letter and number each line, as B′ 2′, C′ 3′, D′ 4′, etc. At any convenient place draw a straight line and erect a line perpendicular to it. Take the length of the line B′ and transfer it to this line,

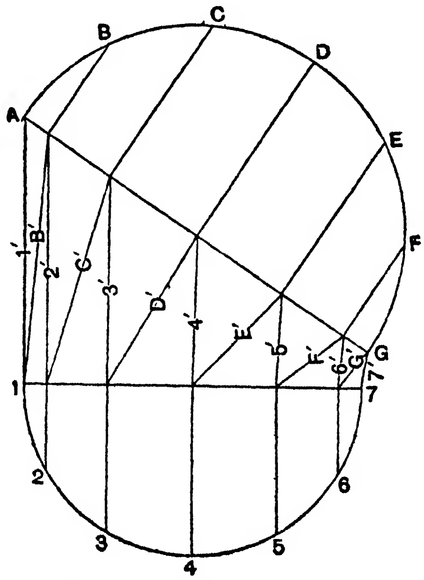


Fig. 252. Development of One Section

as shown, and likewise take the line B in the plan and transfer it to the base line, as in Fig. 253. Connecting these two points gives a right angled triangle, and the hypotenuse, or line B^2, is the true length of B′ in elevation. Erect another perpendicular line and transfer the length of the line marked 2′ to it, as shown. Take the length of the line 2 in plan of small end and transfer it to line B in plan of large end. Take the difference in length of these two lines and mark it off on the base line from the intersection of the perpendicular line as at 2 B.

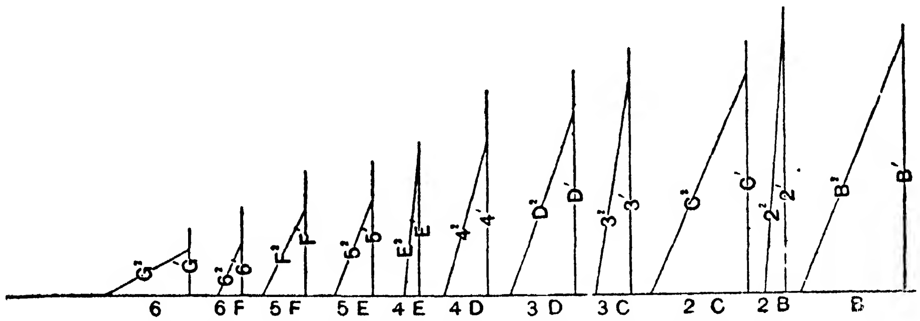


Fig. 253. Determining Lengths of Lines in the Elevation

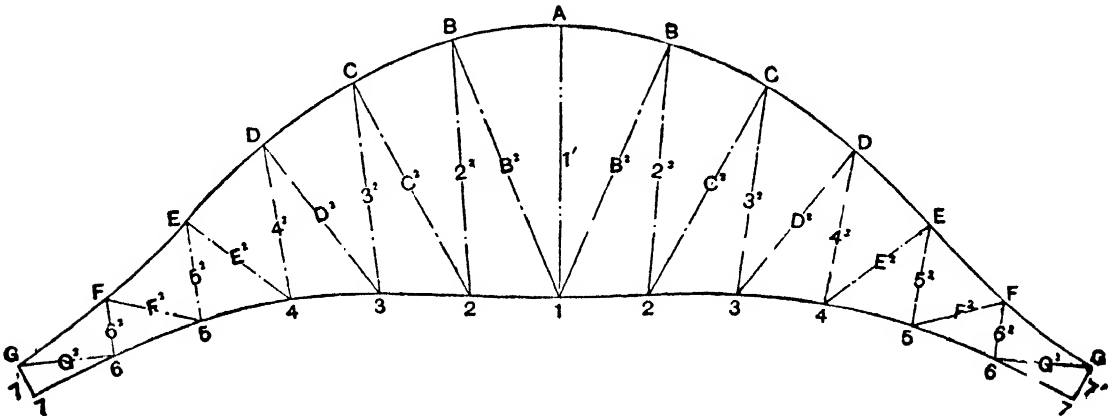


Fig. 254. Development of the Pattern

Connect these two points, giving another right angled triangle, of which the hypotenuse, or line 2^2, is the true length of line 2′ in elevation. This process is now repeated by erecting another perpendicular and transferring the length of line C′ to it, and taking the difference in length of lines 2 and C and transferring it to the base line as before. The points being connected, another right angled triangle is obtained, the hypotenuse, or C^2, being the true length of C′ in elevation.

This process is repeated until all the true lengths of the different triangles have been found, after which all is ready to proceed with the development of the pattern. Accordingly, in any convenient place, draw a line of indefinite length. On this line lay off the distance from 1 to A in elevation, this being the true length of the

center line. Next, with the point A as center and with a radius equal to one of the spacings in the large semicircle, or half plan of top, as A to B, describe an arc of indefinite length. Then, with a radius equal to the length of the hypotenuse of the triangle that represents the true length of the line B′, as at B^2, and with 1 as center, intersect the arc, as at B. Then, with 1 as center and radius equal to 1 2 in plan, describe another arc and intersect, as at 2, with a radius equal to the hypotenuse of the next triangle, using B as center. This process is repeated until the true lengths of all the triangles have been used, finishing with the line G 7 of elevation, which is shown in its true length in that place. A line traced through these points gives the development of the required pattern, minus the necessary laps.

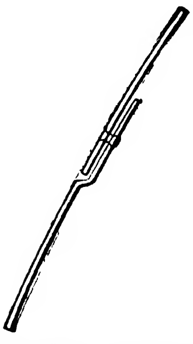


Fig. 255. Method of Making the Seams

This line is termed the rivet line, the necessary holes being laid off on it. Considerable care is necessary in the spacing of these holes in the different patterns, also in transferring the different sections, due allowance being made for the thickness of material. Consequently the top of one section will be smaller than the bottom of the next, so as to allow them to be assembled without too much stretching.

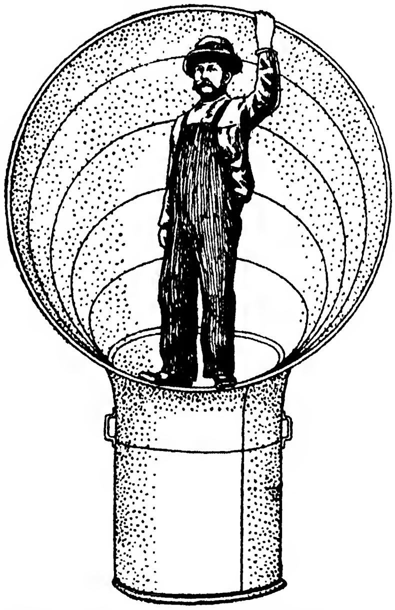


Fig. 256. Front View of Large Cowl

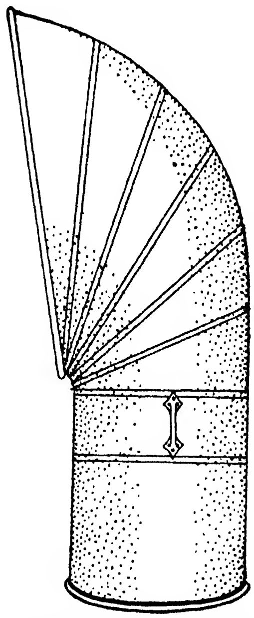


Fig. 257. Side View of Large Cowl

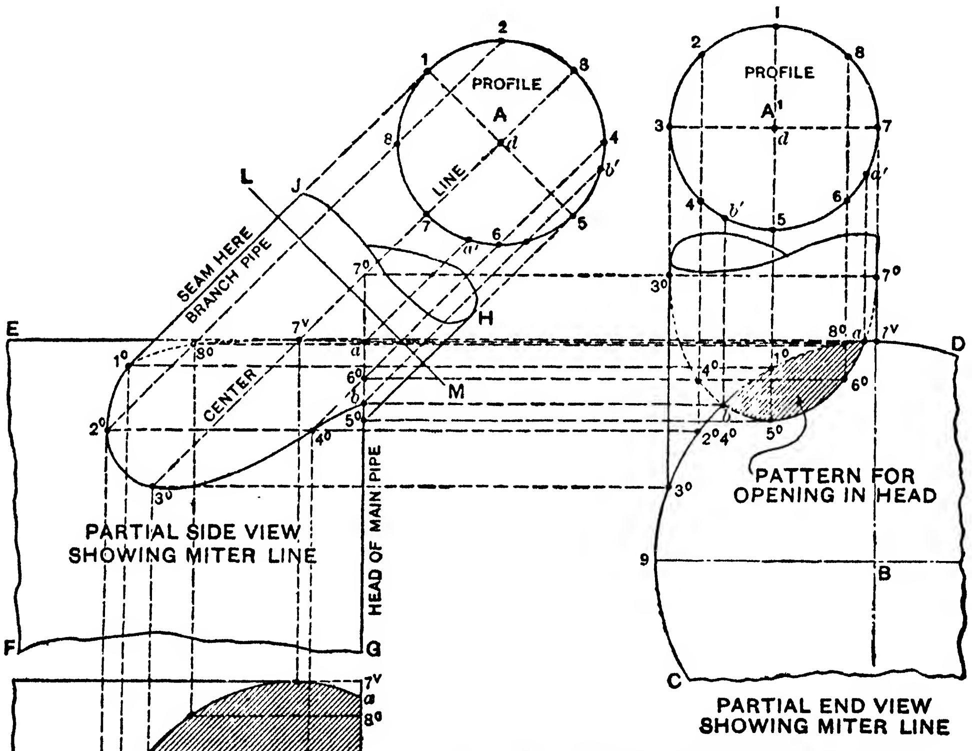
The cowl is raised with a raising hammer until the center line at the back forms a true arc, gradually diminishing each side of the center. The rivets are also countersunk and make the seams as shown in Fig. 255. The seam is soldered on the outside and the surplus solder scraped off, which leaves the cowl perfectly smooth outside, while the three seams inside have a tendency to reinforce and stiffen the cowl. It is also further reinforced by finishing around the mouth with a suitable sized bead iron, the rivets being countersunk to conform to the rest of the cowl.

The material used is galvanized steel which was found to be much superior in regard to lasting qualities to planished iron or black steel. The two illustrations,

Figs. 256 and 257, show an exceptionally large cowl, the diameter of the base of which is 37 in. Consequently the mouth is 74 in. Owing to having no sheets larger than 36×96 in., the rule of four pieces was departed from, as will be noticed from an inspection of the pictures.

PATTERNS FOR AN IRREGULAR T JOINT

To develop the patterns for an irregular T joint, in which the branch pipe is to be 7 in. and is to intersect the main 16-in. pipe to one side of its center, as



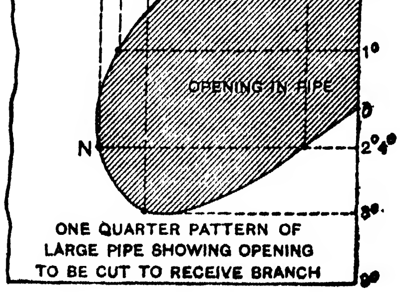


Fig. 258. Method of Obtaining Miter Lines

shown in the end view in Fig. 258, at an angle of 45 degrees, as shown in side view and portion of the pipe is to intersect the end or head of the large pipe, as shown, with the center line of the branch pipe so placed that it will not come in contact with the head of the main pipe; proceed as follows:

All of the above conditions have been observed in Fig. 258 except that the profiles of the pipes are somewhat larger than called for, which allows the principles

to be clearly shown. The locating of the miter lines is the most difficult part of the problem, for after the miter lines have been found the development of the patterns are simple. With the proper size radius and any point as B as center draw a partial end view of the large pipe, as shown by C D. Through B draw the vertical line B 7 and the horizontal line B 9. As the branch pipe is to be placed to one side of the center line then draw at pleasure the horizontal line 7 3, equal to the diameter of the branch, which bisect and obtain *d*. With *d* as center and *d* 3 as radius describe the circle A^1. Divide this profile into equal parts, as shown from 1 to 8, from which points vertical lines are drawn indefinitely, intersecting the curve C D of the main pipe at 1° to 8°, as shown.

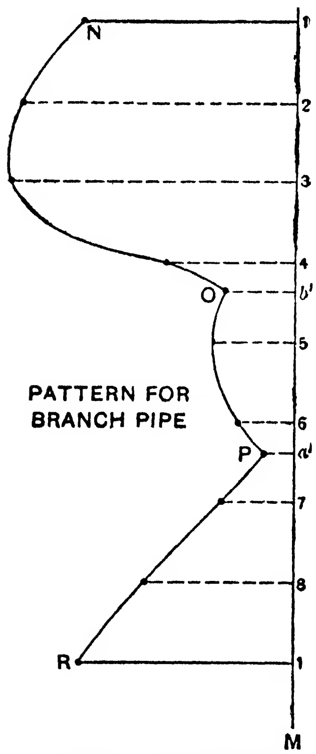


Fig. 259. The Pattern

From the end view project the partial side view of the main pipe, as shown by E *a* G F. As the center line of the branch pipe should not come in contact with the head line *a* G, then let 7^v or any other point be on the center line, and through this point at an angle of 45 degrees draw the line 3°, 3. Establish on this line any point, as *d*, which use as a center, and describe the profile A similar in size to the profile A^1. Through *d* draw the diameter 1 5 perpendicular to the center line 3° 3, and divide A in the same number of spaces as A^1, and if point 1 is at the top in the profile A^1 it will be placed at the top in the profile A, as shown. Through these points, 1 to 8 in A, draw lines parallel to 3 3° indefinitely, as shown.

The first step in obtaining the miter lines is to find out how much of the branch pipe will intersect the head of the main pipe and is done as follows: Extend the head line G *a* of the main pipe until it meets the center line at 7°. Now, where the lines 3 7, 4 6 and 5 drawn from the profile A, cut the head line G 7°, draw horizontal lines in the end view until they intersect similar lines drawn vertically from similar numbers in the profile A^1, as shown by intersections 3°, 4°, 5°, 6° and 7°, thus obtained. Trace the elliptical figure through these points, as shown, and where this elliptical outline cuts the profile of the main pipe at *a* and *b*, are the desired points. From *a* and *b* draw vertical lines to the profile A^1, intersecting same at *a'* to *b'*. The distance from *a'* to *b'* shows the amount that the branch will intersect the head of the main pipe and the shaded portion *b* 5° 6° *a* 8° 1° *b* shows the pattern for the opening to be cut in the head of the main pipe.

Now, take the distances from 4 to b' and 6 to a' in the profile A^1, and place them from 4 to b' between 4 and 5, and 6 to a' between 6 and 7 in the profile A, and from these points a' and b' parallel to the line 3 3°, draw lines until they intersect the head line G 7° at a and b. If these points are in their true position they will be intersected by horizontal lines drawn from a and b in the end view.

To find the miter line of the rest of the branch pipe a' 1 b' with the main pipe, extend horizontal lines from the various intersections on the curve C D in the end view until they intersect similar numbered lines drawn from the profile A in the side view, as shown by the points of intersections a, 7^v, 8°, 1°, 2°, 3°, 4° and b. If desired a curved line can be traced, giving the miter line in both views.

For the pattern for the opening to be cut in the main pipe, take the girth of all the spaces contained in the curve C D in end view from 9 to 7^v, as shown by similar letters and figures placed on the line G 9 below the side view. From these small figures, at right angles to G 9, draw lines, which intersect by lines drawn parallel to G 9, from similar numbered intersections in the miter line in the side view. Trace a line through points thus obtained, as shown by a N b, then will the shaded portion be the desired opening.

The pattern for the branch pipe is shown in Fig. 259, and is obtained as follows: Take the girth of the profile A in Fig. 258 each and every space, and place it on any vertical line L M in Fig. 259, as shown by similar letters and figures. Through these figures at right angles to L M draw lines indefinitely, as shown. At pleasure, at right angles to 3 3° in Fig. 258 draw any line as L M. Now, measuring from this line, L M, take the various distances to points 1° to 5° to a to 1°, and place them on similar lines in Fig. 259, measuring in each instance from the line L M. A line traced through points thus obtained, as shown by N O P R, will be the miter cut for the branch pipe, with the seam at 1 as called for in Fig. 258. The miter cut N O and P R in Fig. 259 joins the curved part of the main pipe, while the miter cut from O to P joins the opening in the head from b to 5° to 6° to a in the end view in Fig. 258.

SHORT RULE FOR CHIMNEY BASE

In Fig. 158 is shown a perspective view of a smoke stack base, in which A is the base, B the flange, which rests on the chimney and is cemented, and C the collar, which fits into the chimney D. When making up the complete base, it is constructed as indicated in Fig. 159, in which the base A has a ½-in. flange at *a*, which is riveted to the collar and the flange B at *b*. It will be noted that the collar and flange are doubled at *c* with a hem edge at *d*. The short rule for obtaining the pattern for the base is shown in Fig. 160, and can be used for any size chimney or pipe. While a full plan is shown, a one-quarter plan is all that is required.

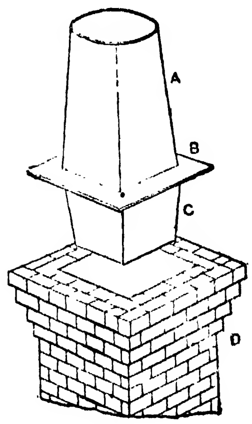


Fig. 158
View of Smokestack Base

Let A B C D show the size of the opening in the chimney and E H the size of the smoke pipe. Draw the two diagonals A C and B D intersecting each other at E, the center point from which the circle is struck, and which intersects the diagonal at H. From H at right angles to E B draw the line H J equal to the hight of the base. Also from E draw the perpendicular E F indefinitely. Draw a line from B through J until it meets the center line at F.

With radii equal to F J and F B and with F^1 as center, draw the arcs L M and D^1 D^2. Starting from D^1 step off on the arc drawn divisions equal to D A, A B, B C and C D in plan, as shown by similar letters in the pattern, from which points connect lines as shown, and add the lap indicated by the dotted line. Take one-half the girth of the circle H in plan and place it on either side of the pattern, as shown from J^1 to M and from J^1 to L. Draw lines from D^1 to M and from D^2 to L. Allow a lap for riveting as shown by M D^1.

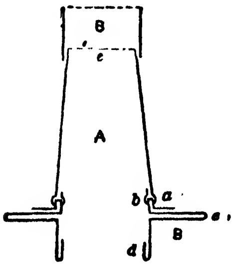


Fig. 159. Construction Indicated

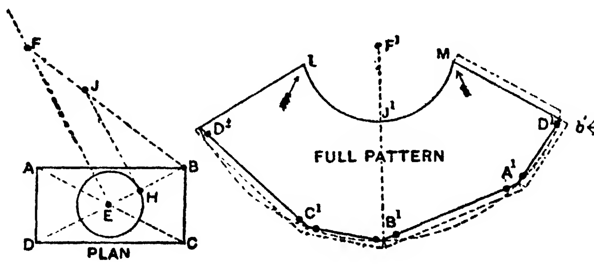


Fig. 160. Pattern for the Base

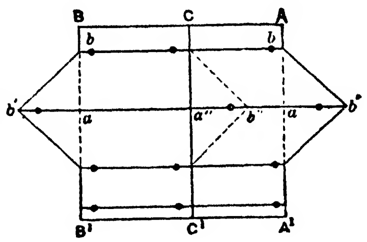


Fig. 161. Pattern for Flange

This results in an accurate pattern, with the exception that the lines D^2 L and D^1 M are not true radial lines, and give an acute angle shown by the arrow points L and M. This will in no way interfere with the pattern nor require any trimming,

because the upper joint of smoke pipe will cover it when lapping as is shown in Fig. 159, when B overlaps A at *e*.

The patterns for the flange and collar combined are shown in Fig. 161. Obtain the girth of *b c d* in Fig. 159 and place it on any vertical line in Fig. 161, through which draw the usual measuring lines, as shown. Take the distances of A B and B C in plan in Fig. 160 and place them, as shown, by A B and B C in Fig. 161. Draw vertical lines A A^1, B B^1 and C C^1. Take the distance from *a* to *b* and place it, as shown, from *a* to *b*′ on both sides, and from *a*″ to *b*″. Connect lines, as shown, A B B^1 A^1 and B C C^1 B^1 are then the patterns for the long and short sides of the flange, to fit into the base, as indicated in Fig. 159.

Sometimes instead of using a flange, the entire chimney is covered the same as an inverted pan. The method here shown gives the best results, though of course, considerable cementing is necessary to make a tight joint with the chimney.

SHORT RULE FOR DRUM ELBOW

In Fig. 162 is shown a view of a finished drum elbow. Fig. 163 shows how to lay out the patterns without using an elevation. First, draw the plan of the elliptical drum shown by A, through which draw the long and short diameters, as shown. Extend the short diameter, as A C, and, using C as center, describe the section of the round pipe. This is shown in plan by B.

To obtain the pattern for this pipe divide C into equal spaces, as shown from 1 to 5 to 1, from which draw horizontal lines intersecting the ellipse A at 1′ to 5′. Extend the line of the round pipe, as D E, and, assuming that the seam is to come at the bottom, lay off on D E in Fig. 163, the stretchout shown from 3 to 3 in C. Through these points, at right angles to D E, draw lines, which intersect by lines drawn from 3′ to 5′ in A parallel to D E. Trace the curved line G F. Then will G F 3 3 be the half pattern for the round pipe.

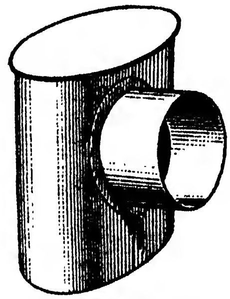


Fig. 162. The Drum Elbow

For the half pattern for the drum and opening establish the points *b* and *c* in A, and take the stretchout of *a*, *b*, 1′ to 5′, *c*, *d*, and place it on a vertical line, as H I. From the numbers draw horizontal lines, which intersect by vertical lines drawn from similar points in the section C. Trace a line through points thus obtained; then will the shaded part N be the shape of the opening to be cut.

Knowing the hight of A in Fig. 163 and the distance that the round pipe is to set below the top, set off these spaces above and below the opening N in Fig. 163, and draw vertical lines through the points obtained, which limit by horizontal lines drawn from a and d in the stretchout. Then will J K L M be the half pattern. When the paper pattern is developed draw a line through 3′, as e f, which represents the proper seam line. Then one-half the opening N should be

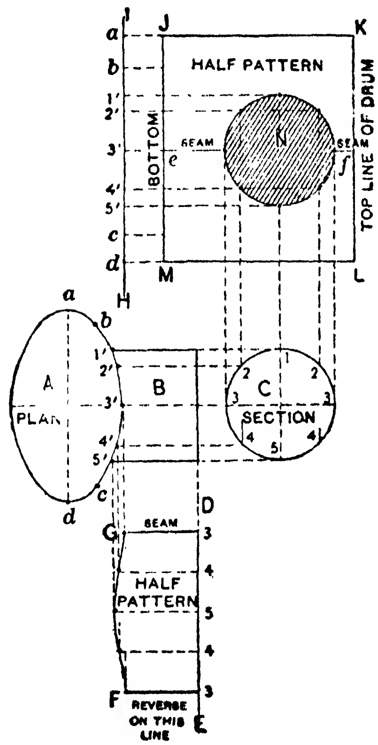


Fig. 163. The Patterns

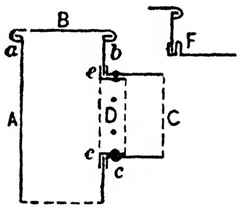


Fig. 164. Sectional View

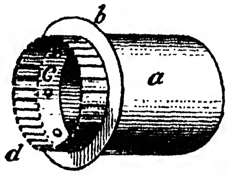


Fig. 165. Notching Collar

placed at either end of the full pattern for the drum, allowing laps for riveting or seaming. The plan A, with edge allowed, answers for the pattern for the top of the drum.

The method of constructing the drum elbow is shown in Fig. 164, where A is the drum and B the top, double seamed at a. C is the round pipe flanged at b, and D a collar, about 2 inches long, riveted to C, and the projecting ½ inch notched and turned against the drum at e e. By this method the body is held firmly between the two flanges b c and e e. In cutting the collar D the same miter cut is used as shown by G F in Fig. 163, but it is made slightly smaller to fit into the round pipe.

Fig. 165 shows the perspective of the round pipe a, with flange b, also the collar c riveted to a and notched at d ½ inch. This extra work of riveting and notching the collar can be avoided if a special machine is used, which is made to form a lock, as shown in F in Fig. 164. If this machine is not at hand, the ordinary thick edge will answer the purpose just as well. The swedge F of Fig. 164 is made as deep as possible with this machine, allowing say ⅜ of an inch edge to project past this swedge and this edge is inserted in the opening of the drum. The elbow is now stood on the collar and this edge thrown over by a heavy bar of iron giving the same appearance as at F. It is to be understood that, in both methods, the cap B of Fig. 164 is placed on last.

PATTERN FOR RANGE CANOPY

In the accompanying illustration is given the pattern for a range canopy, the perspective view in Fig. 166 showing the canopy in position and giving a general idea of its outline. In cutting the pattern let A B C D, Fig. 167, be the front elevation of the canopy and E 6 2 the side elevation. A flange is added from 2 to 1, through which the canopy is fastened to the chimney or wall. To obtain the pattern for the side extend the line 1 E in the side elevation, as shown by F G. Divide the curve 2 6 in the side elevation into an equal number of parts, as shown by the small figures 1 to 6. Place a stretchout of 1 6 on the line F G, as shown from 1 to 6. Through these small figures at right angles to F G draw lines as shown, which intersect with lines drawn at right angles to 6 E from similar points in the side elevation. Trace a line through the points thus obtained, and 1 6 H will be the pattern for the side. No allowance has been made for wire which must be added to the pattern, as the pattern is only developed to the under side of the wire, as shown by 6 in the side elevation.

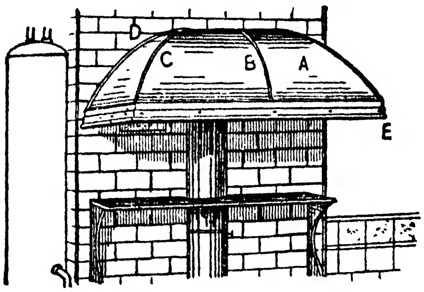


Fig. 166. Perspective View of Range Canopy

The pattern for the front is obtained as follows, using the miter cut on the side pattern: First draw the line J I equal in length to D C. Using the side pattern 1 H 6, place the bottom of the pattern H 6 upon the line J I, placing the corner H of the pattern upon the corner J, and mark the miter J K. Reverse the side pattern, and in precisely the same manner obtain the miter cut I L. Then will K L I J be the pattern for the front. Laps must be allowed on the front and side patterns, to allow flanges to be stretched to obtain a standing seam on the corners, as shown by C in Fig. 166, or by *b′ a b″* in Fig. 168. It will be noticed that at *a* there is a single and a double edge through which rivets are placed at intervals.

A flange must also be allowed to the straight part 1 to 6 of the side pattern in Fig. 167 to allow a flange to be stretched, so that the canopy can be fastened against the chimney D in Fig. 166. It is sometimes the case that the front of the canopy is of such length that a number of sheets are required. In that case straight sheets are placed between by means of the standing seam *e a e′* in Fig. 168 and shown at B in Fig. 166, riveting the same as before mentioned.

Assuming that the canopy has a wired edge, as shown by D in Fig. 168, it is fastened to the wall A by nailing through the flange C, the canopy, if very long, being balanced by means of a neat brass or galvanized chain E. Sometimes the

wire edge is omitted, and a band of iron is bolted or riveted to the lower edge, as shown at E in Fig. 166. The band iron is encased, as shown by F in Fig. 168, in which *b* shows the band or flat iron, the metal *c* from the canopy being bent

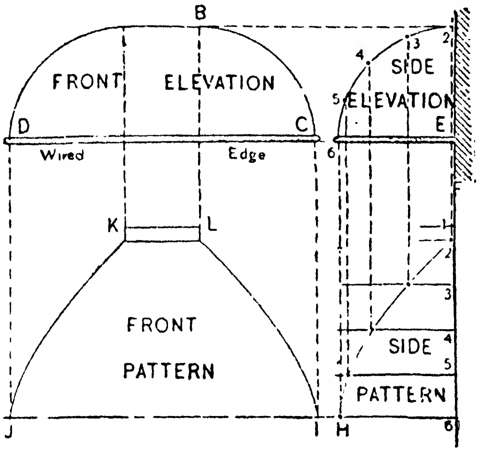


Fig. 167. Elevations and Patterns

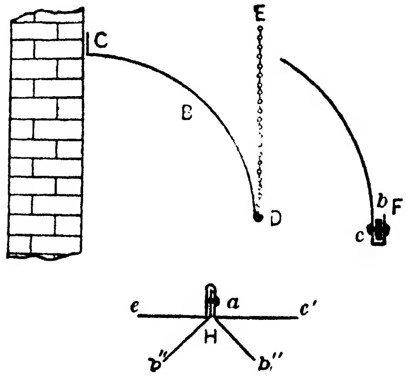


Fig. 168. Details of Construction

around the band iron, as shown, the rivet or bolt being indicated by *c*. Chains are also employed in this case to hold it in a plumb position.

In preparing the flange for the canopy seams, when both pieces to be seamed are curved in completed job, proceed as follows: After the patterns have been developed and allowance made to same for flanging, pass the flange through the

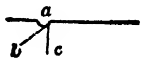


Fig. 169

Fig. 170

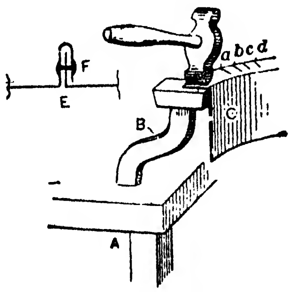


Fig. 171

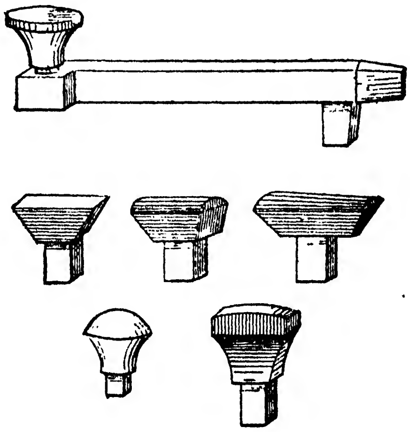


Fig. 172

The Procedure of Making Standing Seams

large turning machine, which will put a small groove along the curve of the pattern and will look as at *a* in Fig. 169. This small groove serves as a guide in stretching the flange, which is gradually turned over the stake at an angle indicated by *b*;

then to a right angle, as at *c*, holding the sheet metal to the required curve by means of a wood template secured to it.

The stretching is done by the use of a stretching hammer, shown in Fig. 170, the faces of which are 1 inch wide, one side being a little sharper than the other, and the edges on both being rounded. The method of using this hammer is shown in Fig. 171, in which A represents part of a bench, in which the square stake B is placed. C shows the article to be stretched. This is done by using the hammer D, just described, and striking along the edges of the flange, as at *a*, *b*, *c* and *d*, being careful to strike each blow with equal strength and at equal distance apart. When the desired curve has almost been reached, use a flat face hammer to flatten the flange and take out the buckles, after which dress down square with the mallet.

In seaming the two sections together one side requires more flange than the other, so as to allow the turning of the left flange over the right one, as shown at F, in E. Knowing the amount that the left flange turns over the right, set the turning machine to the required distance and obtain a small groove along the flange, which acts as a guide, then turn the double flange, which will look as shown at F, when completed. When the pieces are level on the inside, as at E, the rivets F are placed at desired distances. This method of stretching applies to all similar kinds of work.

Fig. 172 shows a double seaming stake, that can be used for this work with six heads. Any desired head can be used in the mandrel, and where the article to be seamed is of such size that the mandrel cannot be used, the heads can be used as hand stakes in large sized metal bodies.

STOVE PIPE RADIATORS OR HEATING DRUMS

Although it may be grammatically correct to speak only of those having a cylindrical form as drums, the term as now used in the sheet metal worker's vocabulary may include various shapes—oval, square, rectangular, etc.—so long as the object of the contrivance is to save heat that might otherwise pass out of the chimney. They are thus economical to the user because they allow a large per cent. of heat to be utilized in heating the house instead of the chimney. They also allow of a more thorough distribution of the heat, as in the case of a chamber through which the stove pipe must pass. In other cases a room may be heated by a hot air pipe leading from another such contrivance. The smoke pipe from a

furnace is often so hot near the chimney that the hand cannot be held upon it; in such cases a hot air drum may be used to advantage.

Plain and annealed sheet iron can now be procured in handy sizes, that the tinner will find very convenient to work up. Among the sizes made, 18×42 inches, about No. 28, will be found perhaps the most useful. Russia iron and its imitation may also be used effectively.

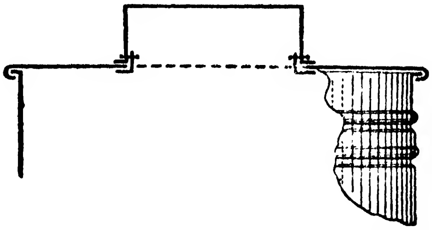


Fig. 173. Section Through Cylinder Drum

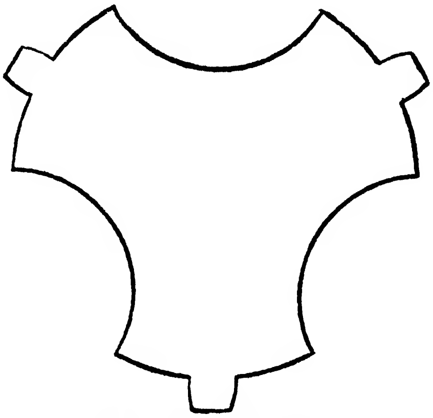


Fig. 174. Baffle Plate

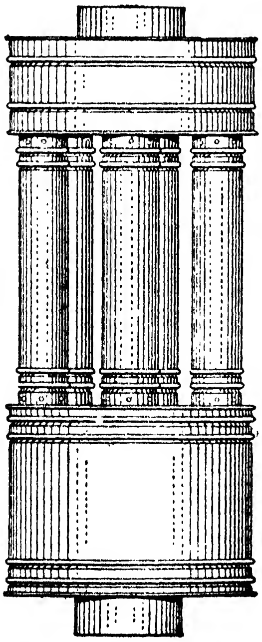


Fig. 175. Pillar Drum

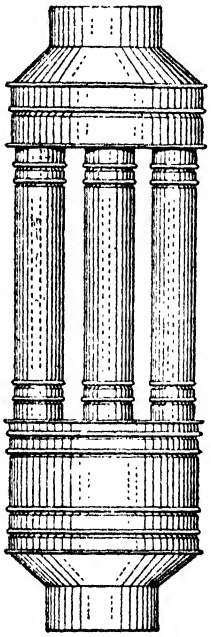


Fig. 176. Sampson Pillar Drum

Many varieties of radiators are in use that can easily be made in any tin shop—viz., the cyclinder, or barrel drum; the plain oval body drum; the pillar drum in connection with round body; the pillar drum in connection with oval body; the descending flue, plain oval body; the descending flue in connection with pillars;

the vertical cylinder drum, with tube; drums with hot air attachments, such as the horizontal, tubular, internal cylinder, etc.

One of the easiest to make, and perhaps the cheapest, is the first mentioned, which is made as follows: For the circumference take three pieces, each 18×24 inches, roll them, and fold along the 24-inch way, then seam them with a mallet on the stove pipe stake, making the surface even on the outside, which gives a better appearance than when seamed with a hand groover. A cyclinder about 16½ inches in diameter and 24 inches deep is the result. Turn an edge at each end with the small turner or large burring machine to take the top and bottom, which should now be cut out, and will need to be about 17⅛ inches in diameter to allow for the edge to be turned over to engage with body. If the body be put through the beading machine, having an ogee swedge in position, it will improve the appearance considerably. The collars at the ends may be formed to fit either 6 or 7-inch pipe, as is desired; if for 6-inch, cut one piece for large end 20⅞×4½ inches, and another the same depth and ¼ inch less in length for small end; for a 7-inch collar cut 23 inches by 4½ deep. Turn an edge on these collars, as shown in Fig. 173, and rivet within them a piece 1½ inches wide, and in length the same as the circumference of the collar, leaving about 3-16 inch projecting past the face of the end, which (when the hole is cut in the drum) is hammered over to secure it to the top or bottom, as the case may be. The construction is clearly shown in Fig. 173, which is alike both top and bottom. A partition, or, as it is sometimes called, a baffle plate, is now made from the pieces that were left after cutting out the ends, and cut to shape, as in Fig. 174, the three projections shown allowing it to be riveted horizontally in the center of the drum. If it is desired to use feet as an additional support, provision must be made for them before putting on the bottom, by riveting thereon three pieces of hoop iron, suitably bent, so as to allow of the insertion or removal of the feet at any time.

In Fig. 175 is shown a useful size of pillar drum. The upper section is made from three pieces of the same material as the preceeding one, each 17⅛×6 inches wide. The best way is to first cut pieces for the ends of the two cylinders—namely, four pieces 18 inches square—thus leaving a piece off each sheet 6×18 inches, three of which will make the upper section previously mentioned. Three pieces 17⅞ inches by 12 wide, put together will make the lower section. Five pillars are used, each 12 inches in circumference and 18 inches long. A small fold is required on these, so that they may be grooved on the machine. The ends of these pillars are fastened in the same manner as the collars shown in Fig. 173 and should be the first thing done when putting the drum together; then the lower and

upper sections (each having an end and collar attached) can be finally joined. They may be used with or without feet, but it is customary to provide three feet.

A very attractive and efficient heater is shown in Fig. 176, which is known as "Samson," a good name too, strong to heat and to wear. The pillars, six in number, are each made from sheets $10 \times 17\frac{3}{4}$ inches and are about 3 inches in diameter when finished. Two pieces $4 \times 17\frac{3}{4}$ inches and one piece $4 \times 4\frac{3}{4}$ inches make the circumference of the upper section, and two pieces $8 \times 17\frac{3}{4}$ inches and one piece $8 \times 4\frac{3}{4}$ inches the lower section. The diameter of drum will thus be about 12 inches after allowing for seams. To obtain the cones proceed as follows: With the square set off two lines, as A and B, Fig. 177. Make A C equal to one-half the diameter of large end or base of cone; from C to D is the straight hight, in this case 2 inches. Make E D equal half the diameter of smoke pipe. Draw a line through A E, intersecting B at F. With the compass set from F to A, at any convenient place describe the circle *a a*. Then with the distance F E describe the circle *b b*. With the dividers set from A to C, step off around the outer circle six times and draw lines to the center, and make allowance for all edges needed, as shown by the dotted lines. Put together in the same manner as the aforementioned. No feet are required, but the collars should fit the pipe snugly.

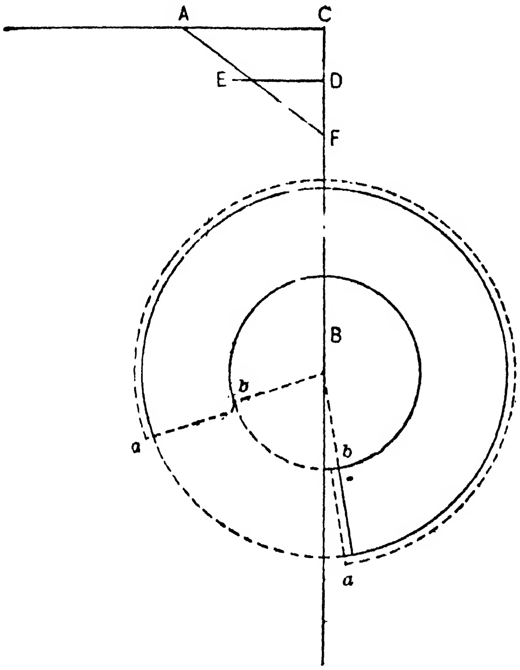


Fig. 177. Pattern for Drum Top

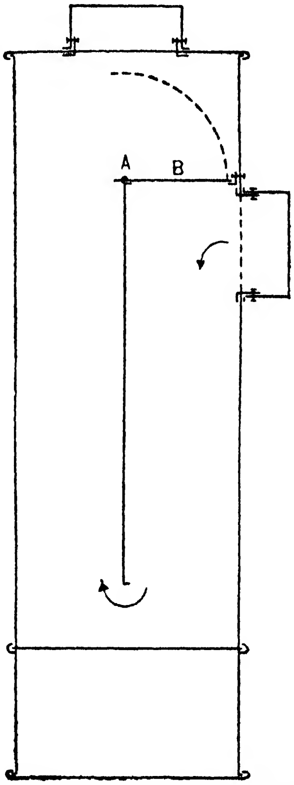


Fig. 178. Section of Descending Flue Drum

In some places an oval shape drum may be more desirable than a round one. A cheap one may be made after the manner of the cylinder drum, Fig. 173, the same size, only after swedging form up to an oval 14×19, approximately.

The descending flue, plain oval body, is made in different hights to suit customers. A popular size is shown in section in Fig. 178. It is the same circumference as the plain oval, only, as it is made twice as deep, provision must be made for a small end so as to allow a slip joint to be made in the center, after the manner of a stove pipe. To obtain the oval end proceed as shown in Fig. 179.

Make A B equal to the desired length, 19 inches. Make C D equal the width, or 14 inches. With the compasses set half the distance from A to B and with one leg at C describe the arc E F. Drive pins at E, F and C. Tie a string at E and F, passing around C, then remove C and substitute the point of a lead pencil, which, when moved around, keeping the string tight, will describe

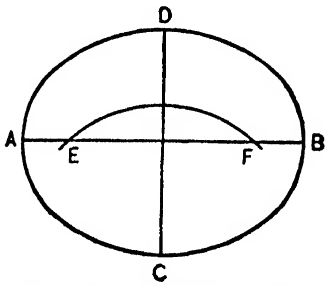


Fig. 179. To Draw an Oval

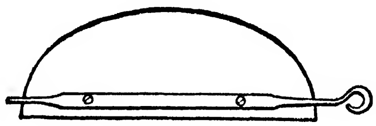


Fig. 180. Plan of Damper

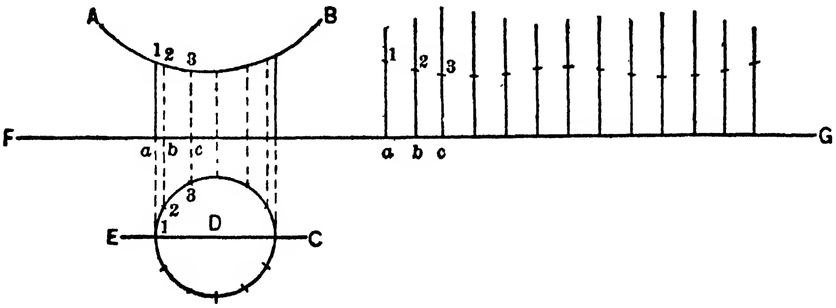


Fig. 181. Pattern for Intersection of Collar

the required oval. The cut, Fig. 178, shows a straight partition, commencing about 1 inch above the inlet collar and extending to within 6 inches of the bottom of drum. This is riveted to the sides for support. At the point A is pivoted the damper B, which when turned, as shown by the dotted lines, allows the smoke to go directly to the chimney. Fig. 180 shows the manner of attaching the handle to the damper by means of two stove bolts passed through that part of the handle which has been flattened for the purpose. A base is provided for this

style of drum 8 or 9 inches deep, wired at the lower edge and perforated. The collar at the side will need to be made on a curve in order to fit properly. To obtain the pattern let A B, Fig. 181, represent the curvature to which the collar is required to fit. Draw the plan D below it and in line with the elevation. Divide it into any equal number of parts and draw line at right angles to E C, cutting the curved line where numbered. Parallel to E C draw the stretchout line F G. With the dividers set equal to one of the spaces in D, step along E G as many times as will equal the circumference of D. Erect perpendiculars as shown, numbering them in order to avoid confusion. These lines are called measuring lines. Transfer the length of the lines in elevation to the corresponding measuring lines—viz.: Make *a* 1 of the measuring lines equal *a* 1 in the elevation, *b* 2 of the measuring lines equal to *b* 2 of elevation, and so on. A line traced through these points will give the pattern required.

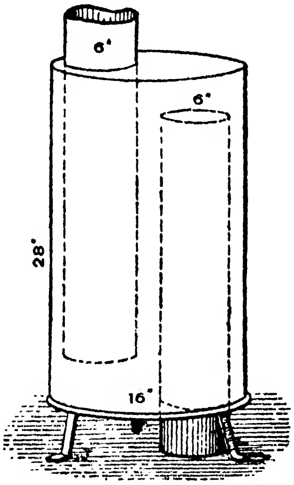


Fig. 182. A Heating Drum

The oval drum with pillars may be made of the same dimensions as Fig. 175, the body being formed oval instead of round and the pillars adjusted to suit the difference in shape.

Another drum, shown by Fig. 182, can be made of Russia iron, 28 inches high and from 14 to 17 inches in diameter, or of smooth black iron 24 inches high and 16 inches in diameter. Continue the pipe or collar on the bottom of the drum upon the inside to about 6 inches from the top, and the outlet pipe at the top of the drum is carried down to within 6 inches of the bottom, as shown in the sketch. This brings the hot smoke to the top of the drum, so that a pan of water can be easily warmed, then the smoke gives off its heat to the drum as it falls to the bottom and passes off through the outlet. The legs are made of the straps that come around bundles of sheet iron and should be about 6 inches high.

A HOPPER REGISTER BOX

In the illustration, Fig. 183, is shown the hopper register box, and it will at once be noted that the boxes, after the patterns are cut, are very easily made and are good goods to handle and show prospective customers when talking up work. It will be readily seen that the air starts to spread over the full surface of the register from the collar to the top of box, and there is nothing to interfere in any way with the register valves or a free outflow of the air.

The way to get the patterns for this box is a simple problem in triangulation, and it is advisable to use this method in getting out the patterns for all stock sizes at least. The hopper is shown in elevation by A B C F E D in Fig. 184. The top square part made to receive the register is represented by A B C D, the hopper proper by D C F E, and the round collar at the bottom of the hopper, to which is fitted the hot air pipe, by E F G H. The half plan of the top of the

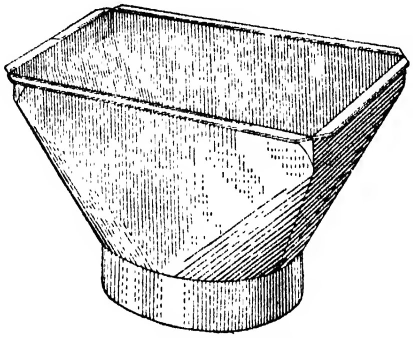


Fig. 183. A Hopper Register Box

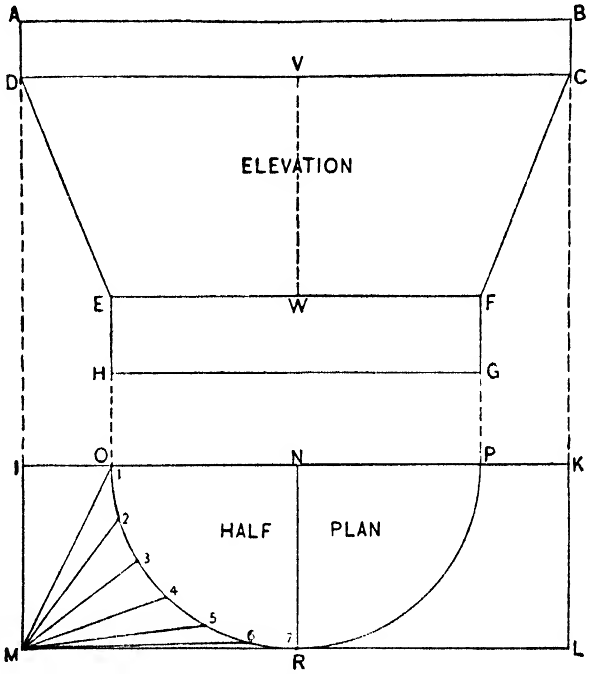


Fig. 184. Plan and Elevation

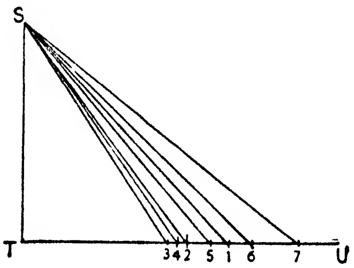


Fig. 185. Diagram of Triangles

hopper is represented by I K L M and the half plan of the round bottom part by O R P. To find the pattern of the hopper, D C F E, and the top square part, A B C D, which are made in one piece, divide the quadrant O R into any number of equal spaces, as shown by the figures 1, 2, 3, 4, 5, 6 and 7. From the point M draw the lines M 1, M 2, M 3, M 4, M 5 and M 6, which show the horizontal distances between the point represented by M in plan and D in elevation and the points on the quadrant.

To find the true distances between this point and the points on the quadrant, draw in Fig. 185 the base line T U. At T erect the perpendicular T S, equal to the vertical distances between D C and E F in Fig. 184. From T on the line T U lay off the horizontal distances between M and the points on the quadrant, making T 1 equal to M 1, T 2 equal to M 2, etc. From the numbered points thus obtained on the line T U draw lines to S. These lines will represent the

true distances from M in plan, which is the same as D in elevation, to the numbered points on the quadrant O R in plan, which is E W in elevation.

To make the pattern as shown in Fig. 186 draw A′ B′ C′ D′ equal to A B C D in Fig. 184. It will be seen from the plan in Fig. 184 that the line L M and the point 7 of the arc O R P meet at R, so that the vertical distance between the points V and W in Fig. 184 is equal to the actual distance between these lines. Therefore, in Fig. 186 let fall from the center of C′ D′ a perpendicu-

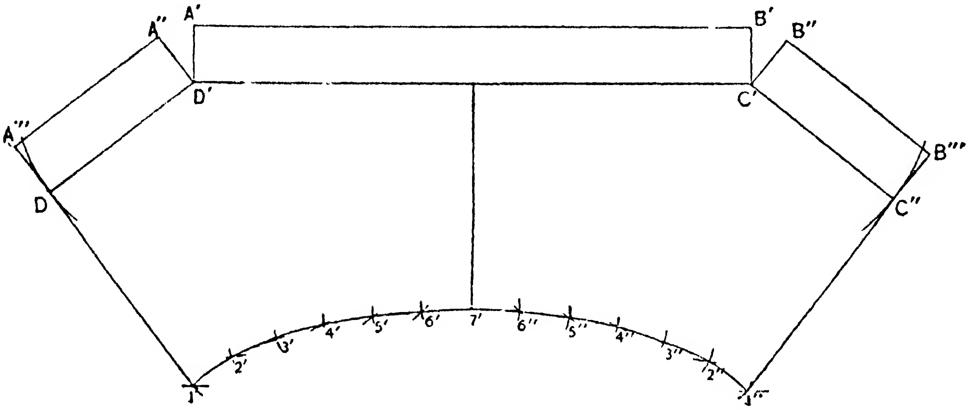


Fig. 186. Pattern for Half of Hopper

lar with a length equal to V W, the vertical distance between D C and E H in Fig. 184, and call the bottom point of the line 7′. Now from 7′, with a radius equal to one of the spaces on the quadrant O R in Fig. 184, strike arcs, and from D′ and C′, with a radius equal to S 6 in Fig. 185, draw arcs intersecting these, marking the intersections 6′. From the points 6′ strike arcs with a radius equal to the spaces in the quadrant in Fig. 184, and intersect these with arcs having centers at D′ and C′, and which have a radius equal to S 5 in Fig. 185, calling these points 5′. Proceed in a similar manner until points 1′ are reached. Trace a curve through the points thus obtained.

From D′ and C′ in Fig. 186 strike arcs equal to I M in half plan in Fig. 184 and intersect these with arcs struck from 1′, with a radius equal to D E in Fig. 184, calling the intersections D″ and C″. Draw the lines D″ D′ and C′ C″. From the points D″, D′, C′ and C″ erect perpendiculars equal to A D in Fig. 184, and connect the top of these perpendiculars, so as to form the rectangles A‴ A″ D′ D″ and C′ B″ B‴ C″. Draw the lines D″ 1′ and C″ 1′. Then will the figure A‴ A″ D′ A′ B′ C′ B″ B‴ 1′ 7′ 1′ be the pattern for half the hopper, no allowance being made for laps.

Attention is called to the way that the joints on the square top of the hopper are made, as shown in Fig. 183, and also to the floor flange which has been pro-

vided and which is an essential part of the hopper. It is usual to make the square box to receive the register about 2 inches deep. As shown in the illustration, Fig. 183, the joints at the corners of this part are simply lapped; if desired these corners can be double seamed, which makes a neater job. After forming up and grooving, a collar is put on the bottom of the box, as shown in Fig. 183, the joints of which are made as in Fig. 188.

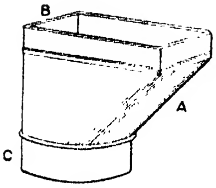


Fig. 187

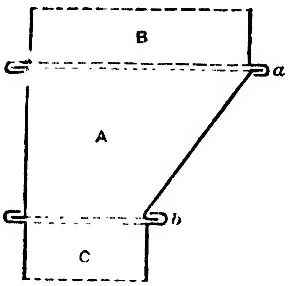


Fig. 188

View and Section Through Offset

The principles explained in the foregoing also apply to "starters," that is, transition pieces, which referring to the transition offset shown in Fig. 187 the part marked A joins a rectangular pipe at B, and a round pipe at C, while Fig. 188 shows how the various pieces B, A and C are seamed together at *a* and *b*. The pattern for an offset of this or any other similar kind is developed by triangulation, as shown in Fig. 186.

PATTERN FOR OFFSET BOOT

The pattern for a boot shown in Fig. 189 is obtained by triangulation without using the plan, and is a method that can be used to advantage when both halves of the article to be made are symmetrical as shown in the plan view in Fig. 190. This method is applicable to any shaped boot, regardless of the size of the pipes at either end or the amount of offset it may contain.

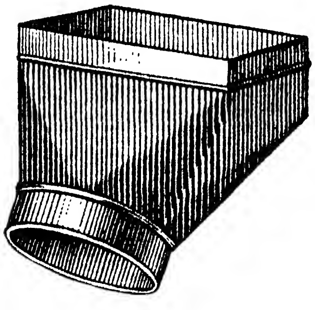
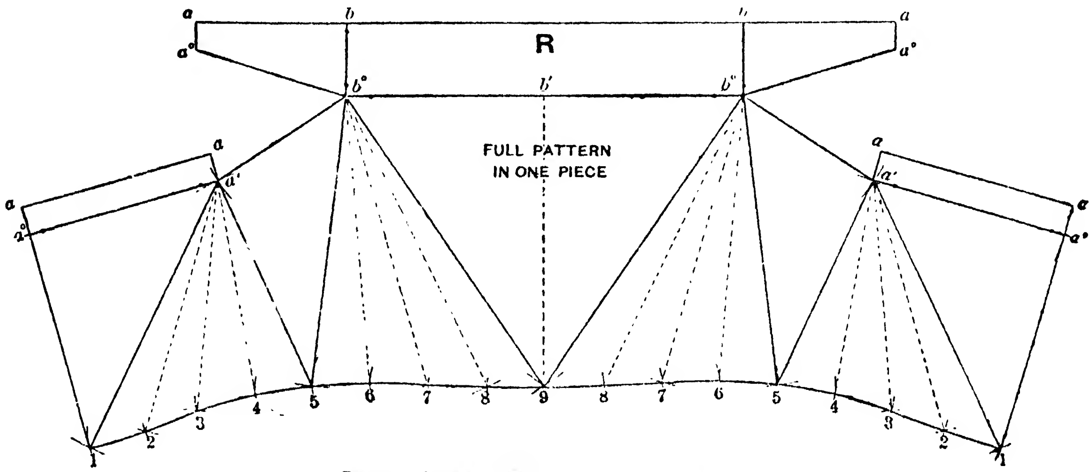


Fig. 189
A One-Piece Offset Boot

First draw the side elevation of the boot as shown by *a b* 9 1, the profile of the pipe on the line *a b* being a rectangle as shown in plan, and the profile on the line 9 1 being a circle, also shown fore-shortened in the plan. On the line *a b* in elevation place one-half of the rectangular profile $a\ a'\ b'\ b$ in plan as shown by similar letters in elevation; and on the line 1 9 place a semicircle representing the one-half profile of the round pipe. As before mentioned, the plan view is not necessary, as the profile of the rectangular pipe would be known without a plan. Divide the semicircle into an even number of spaces as shown from 1 to 9, from which points at right angles to 1 9 draw lines until they intersect the base line from 2° to 8°. All points from 1 to 5° are connected to a^{c} and all points from 5° to 9 are

connected to b°. These lines then give the base lines of sections which will be constructed with altitudes equal to the various hights in both semiprofiles. For example, to obtain the true lengths in Y, take the distances from b° to 5°, b° to 6°, to 7°, to 8° and to 9, and place them on the horizontal line in T as shown by similar numbers. From b° in T erect the perpendicular $b^\circ\ b'$ equal in hight to



Pattern for an Offset Boot in One Piece.

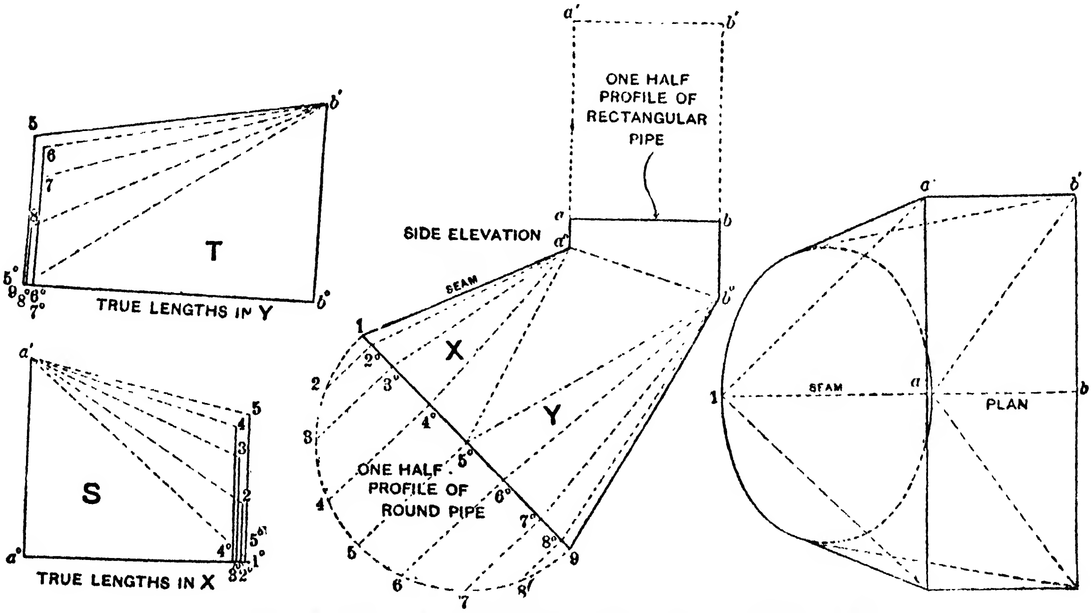


Fig. 190. Details in Obtaining Patterns for an Offset Boot

$b\ b'$ in the half profile. From the points 5°, 6°, 7° and 8° in T erect the perpendiculars $5^\circ\ 5$, $6^\circ\ 6$, $7^\circ\ 7$ and $8^\circ\ 8$ equal in hight to $5^\circ\ 5$, $6^\circ\ 6$, $7^\circ\ 7$, $8^\circ\ 8$, respectively, in the semicircle in elevation. Then draw lines in T from b' to 5, b' to 6, to 7, to 8 and to 9, each of which represents the true length of a similar numbered line in elevation. In a similar manner obtain the true lengths of the lines in X.

Before laying out the pattern the location of the seam must be known, and in this case the seam will be placed along 1 a° in elevation, which would be at 1 a when viewed in plan. The pattern can now be laid out by taking the distance of 9 b° in elevation and placing it on the vertical line in R, as shown by 9 b'. At right angles to 9 b', through b' draw the line b° b°, making b' b° on both sides equal to b b' in the half profile. Draw lines from b° to 9 in R, which will equal b' 9 in T. With radii equal to b' 8, b' 7, 6 and 5 in T and with b° in R as center, describe the short arcs 8, 7, 6 and 5. Now set the dividers equal to one of the equal spaces in the semicircle in elevation and, starting from point 9 in T, step to arc 8, then to 7, to 6 and to 5, and draw a line from 5 to b°. Next with b° a°

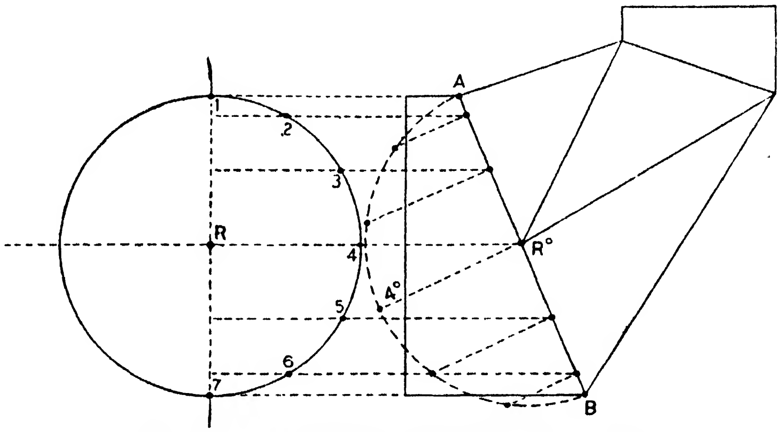


Fig. 191. Boot for Connecting Horizontal Pipe

in elevation as radius, and b° in R as center, describe the arc a', which intersect by an arc struck from 5 as center, with 5 a' in S as radius. Connect lines in R, from 5 to a' to b°, as shown. With radii equal to a' 4, a' 3, 2 and 1 in S, and with a' in R as center, describe short arcs 4, 3, 2 and 1. Then again using the spaces in the semicircle in elevation, step from point 5 to arc 4, to 3, to 2 and to 1, and draw a line from 1 to a'. With the seam line 1 a° in elevation as radius, and 1 in R as center, describe the arc a°, which intersect by an arc struck from a' as center and with radius equal to a a' in the half rectangular profile in elevation. Connect lines in R from 1 to a° to a' and trace a line through the intersections from 1 to 9 on both sides. Then will 1, 9, 1, a°, a', b°, b°, a', a° be the net pattern for the transition piece.

To add the rectangular part shown at the top in Fig. 189, simply take the distance from b° to b in elevation and place it perpendicular to b° b° in the pattern as shown by b' b, and draw a line from b to b. Take a tracing of a b b° a° in elevation and place it as shown by a b b° a° in the pattern. Take the distance of a° a and place it perpendicular to a^1 a° in the pattern and draw the

line *a a*. This then completes the pattern for the offset boot in one piece, to which edges must be allowed for seaming purposes.

It is to be understood that, if this arrangement precludes cutting from stock material, the collar R can be made separately; also a seam could be provided on line *b'* 9. This method is applicable for a boot that is to connect to a horizontal round pipe and would look like Fig. 191. A slight change of procedure is necessary, inasmuch as a section on line A B is an ellipse. This section is ascertained by dividing the circle X into equal parts and carrying lines from these points to the line A B. At right angles to A B and from where these lines intersect it, erect lines that are equal in length to the distance from the center line of the circle; as, 4°—R° of line A B equals 4 R of the circular section.

SHORT RULE FOR STRAIGHT BOOT PATTERN

In Fig. 192 is shown a finished view of a straight boot from oblong to round used in ventilation and heating work. In this article the proposition is to obtain the half-pattern for A, with seams at the sides, as shown by B by a short rule. The usual rule is to obtain the plan and elevation of the article, then divide the plan in equal spaces and obtain the base lines of the sections the vertical hights of which would be equal to the hight of the article. In this case the plan is omitted, as will be seen in Fig. 193, which shows a simple method for obtaining an accurate pattern.

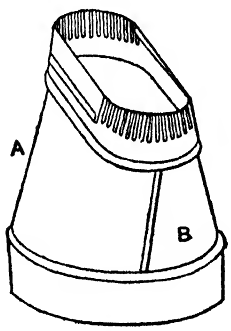


Fig. 192. View of the Finished Boot

First draw the center line, upon which place the hight the boot is to have, as shown by *a* 1'. Draw horizontal lines through *a* and 1', making 5 5' equal to the length of the oblong pipe, and 4 4' equal to the diameter of the round pipe.

Place the half profile of the oblong pipe in the position shown by C, and the half profile of the round pipe in the position shown by B. As the four quarters of the article are alike it is only necessary to divide the quarter circle in B in equal spaces, as shown from 1 to 4, and the quarter circle in C into a similar number of spaces, as shown from 5 to 8, 8 8' being the semidiameter of the circular ends of the oblong pipe.

From the various divisions 1 to 4 and 5 8 lines are drawn at right angles to their respective base lines, intersecting them from 1' to 4 and 5 to 8'. Solid and dotted lines in A are now drawn, as shown, which represent the bases of sections to be constructed, the altitudes of which are equal to the various hights in the semi-

profiles B and C. For example, the true section on 1′ 8′ in A is obtained by placing this distance on the horizontal line 1′ 8′ in D and erecting the perpendiculars 1′ 1 and 8′ 8, equal, respectively, to 1′ 1 in B and 8′ 8 in C; 1 8 in D then gives the true length on the finished article on the line 1′ 8′ in A. Diagram D shows the true lengths of the solid lines in A, while in E are shown the true lengths of the dotted lines in A.

The pattern for one-half the boot is shown in Fig. 194, in which the distance 9 8 is equal to 9 8 in C in Fig. 193. With the radius equal to 1 8 in D and 8 and

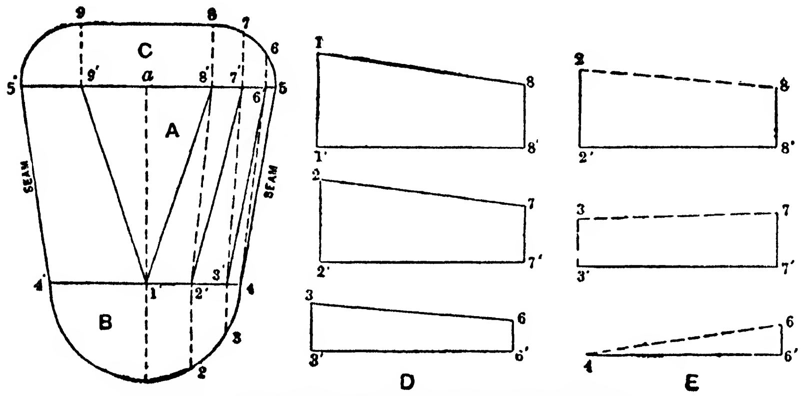


Fig. 193. Elevation, Half Profiles and Sections

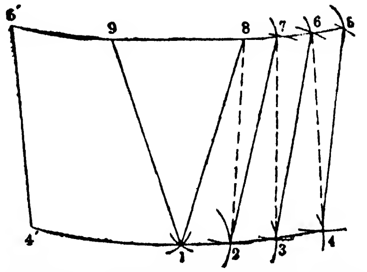


Fig. 194. The Half-Pattern Shape

9 in Fig. 194 as centers, arcs are struck intersecting each other at 1. With 1 as center describe the arc 1 2 with a radius equal to 1 2 in B in Fig. 193. With radius equal to 2 8 in diagram E and 8 in Fig. 194 as center intersect the arc 2 at 2.

Using 8 as center, describe the arc 7 with a radius equal to 8 7 in C in Fig. 193. Then using 2 7 in diagram D as radius and 2 in Fig. 194 as center describe an arc intersecting the arc 7.

Proceed in this manner, using alternately first the divisions in the profile B, in Fig. 193, then the true length in E, the divisions in the profile C, then the true length in D, until the line 4 5 in Fig. 194 is drawn, which is obtained from 4 5 in A, in Fig. 193. Trace 1 4, 5 8 in Fig. 194 opposite the line 1 9, as shown by 1 4′, 5′ 9 which completes the half-pattern, to which edges must be allowed for seaming.

PATTERN FOR FURNACE PIPE FITTING

The following is a demonstration of the method of obtaining the pattern for a furnace pipe fitting shown by Fig. 195. As will be seen, this is a transition fitting, which makes a quarter twist for a line of piping. It is emphasized that such a fit-

ting is frequently useful between a floor and the ceiling below, where a square box with collars attached is generally used. This, of course, is unscientific and requires more space, necessitating considerable additional cutting away of the timber. Naturally, such a fitting affords, in a large measure, obstruction to the flow of the air, as it does not provide an easy transition from one portion of the line of piping to another, whether the line is vertical or otherwise.

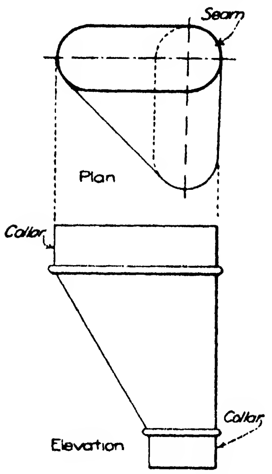


Fig. 195. Pattern Problem

In laying out this article a plan is the first essential. The plan of Fig. 195 is to be redrawn as in Fig. 196. By studying the problem it becomes evident that the object is composed of triangular and cylindrical surfaces which alternate. Inasmuch as the elements of a cylindrical form are always parallel, the obvious conclusion, it would seem, is to develop these surfaces by the parallel line method. As three of these surfaces are inclined, however, with but one vertical, and its true section shown by the plan, this surface being the one designated 13 to 17, the question arises, would the method suggested be preferable to triangulation?—because true sections are, perforce, required of the inclined surfaces to develop the pattern by the parallel method.

By experimenting with both methods, it is learned that the parallel methods are decidedly quicker and insure the greater accuracy by reason of the elimination of the dotted lines required by triangulation to connect the elements. For this exemplification, therefore, the procedure will be by the parallel method.

The plan is divided into spaces as shown by 1 to 30, and the elements of the various cylindrical surfaces represented by dot and dash lines as shown. The triangular surfaces are also shown by certain lines, as 13 30, 9 26 8, 21 4 22. It is purely a fortunate accident that some lines pass through two points, as line 4 26 is for two triangles.

The true sections of the cylindrical surface are determined in this wise: For the surface 9 13 to 30 26 an elevation is drawn by projecting the division points upward. On the line 31 32 the hight of the fitting is placed. Horizontal line 32 33 terminates the elements at the top, and line 31 34 at the bottom. From the point where the projectors drawn from 30 to 26 in plan intersect line 31 34, lines (the elements) are drawn to where projectors from 13 to 9 intersect line 32 33. These lines are parallel, and 32 33 34 31 is a partial elevation of the fitting, giving the exact lengths of the lines of the triangular surface 13 30 in plan, also of the element of the cylindrical surface 13 9 30 26 of the plan. Although it is not a true eleva-

tion, it will suffice for the triangular surface 17 0 and cylindrical surface 17 21 0 4 of the plan.

The ascertaining of the true section is now in order and is done in this fashion: A line A B is drawn perpendicular to the elements in the elevation. Measuring from this line on each element, the distances in plan are placed, as 30 R in plan is 35 S in elevation, etc.

An oblique view is necessary for the finding of the right lengths of the elements and the true section of the surface 26 22 8 4 as follows: A line 36 37 is drawn parallel to the plan lines and another line 38 39 the distance away of 31 32. Projection lines are drawn to this from the plan, as instructed for the other elevations. In a like manner the true section is found on the line, using the distances as 23 P in plan is 40 Q in the elevation. The triangular surface is not shown true in this elevation, owing to the plane in plan 8 9 26 being fore-shortened in elevation 37 39 41.

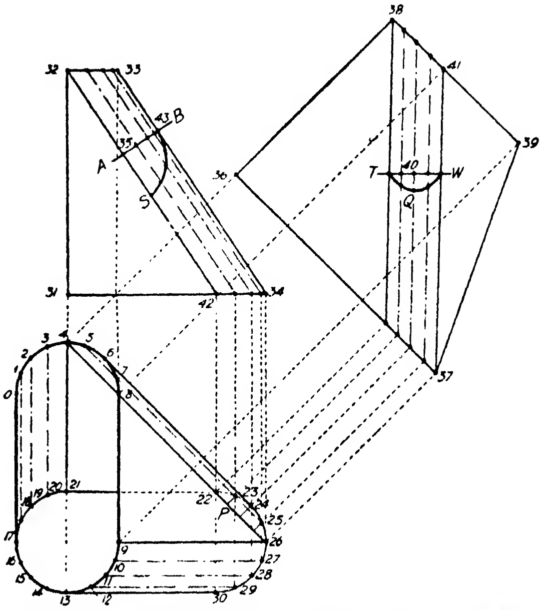


Fig. 196. Development of Elements of Fitting

The sides of this triangle having been already obtained in the elements of the curved surfaces, also the other slanting triangular surface 4 21 23, no further work is required, leaving the developing of the pattern still to be accomplished, to wit: As the seam is stipulated to be at point 16 in plan, a stretchout of that surface is placed anywhere, as 16 to 13 in Fig. 197. To this is annexed the triangular surface 13 30 in plan; that is, 32 31 42 in elevation is transferred to the pattern, as shown by 13 T 30 13. To these are attached the stretchout of the cylindrical surface 13 9 30 26 in plan, by drawing, in Fig. 197, a line A A B B with the stretchout points of the true profile perpendicular to 13 T 30 the same distance from 13 T that A B of Fig. 196 is from 32. The most convenient way to carry the elements to the pattern is to take the distances on the various elements in Fig. 196 from line A B to 32 33 and A B to 42 34; like the space 33 43 of Fig. 196 coincides with 9 43 of Fig. 197.

Line 9 26 of Fig. 197 is one side of the triangular surface 9 26 8 of the plan, Fig. 196. With the compasses or trammels spaced to 9 8 of Fig. 196, swing an arc from 9 as a center, Fig. 197. With the compasses now set to the distance

37 41 of the oblique elevation, Fig. 196, and 26 as center, Fig. 197, swing an arc to intersect the arc just drawn, giving the point 8 or the exact triangular surface.

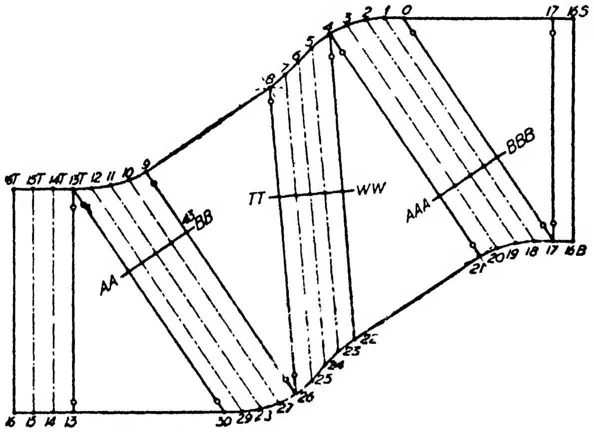


Fig. 197. Development of Pattern

The elements of the cylindrical surface 26 22 8 4, Fig. 196, are appended to this much of the pattern, as per former instructions. The triangular surface 21 4 22 of Fig. 196 is obtained by swinging an arc of a length coincident to 21 22 of Fig. 196 with 22 as a center in Fig. 197. From 4 swing an intersecting arc of a length equal to 42 32 of Fig. 196.

The rest of the pattern is simply the repetition of the first part of the pattern, from 14 T to 9 to 14 to 26 as shown; inasmuch, as stated, the elevation of Fig. 196 would suffice for two of the cylindrical and triangular surfaces combined. In conclusion, it is suggested that the pattern be made in two parts with an additional seam at, say, line 7 26. This is suggested to allow of cutting with little waste from standard sizes of tin plate.

From the foregoing solution the method of obtaining the pattern for a fitting of an oblong pipe, that is to say, a pipe with four flat sides or rectangular in section, should be clear, because flat surfaces are only dealt with, making it much more simple.

PIPE INSERTING FURNACE TOP

In Fig. 198 A B C D represents part of the furnace top and E F J G the pipe, which joins the top at an angle in elevation indicated by B K E, and at an angle in plan, Fig. 199, by Z. In this connection it may be proper to remark that no matter what size of furnace top or what size pipe is used, or at what angle the pipe is placed in plan or elevation, the principles here shown are applicable in any case. Referring to Fig. 199 let A B C D represent the elevation of the furnace top, the half-plan of which is shown by E F G H I J K. Let J G in plan represent the angle at which the pipe is to be taken off the top, and let L in elevation represent the hight which the side of the pipe H of Fig. 198 will be above the base line of the cone in elevation in Fig. 199. At right angles to D C, and from the point L, draw a line intersecting the center line E H of the plan at T^1. With J in plan as center, and J T^1 as radius, describe an arc intersecting the line J F,

which is drawn at right angles to J, G, at X^1. Then at pleasure locate the point where the side of the pipe, indicated at H of Figs. 198 or 200 in the profile N of Fig. 199, should touch in plan, as shown by the point M. Now through the point M, and parallel to J G, draw the line M S, prolonging it until it intersects the line J F at R. At right angles to R S draw the line S P, equal to the width of the pipe, and parallel to R S the line P O, as shown. In line with the pipe draw the profile N, which divide into equal spaces, as shown by the small figures. Through the small figures, and parallel to P O, draw lines intersecting the arc G F and line J F, as shown by O Z, S T, V U, W X and R Y.

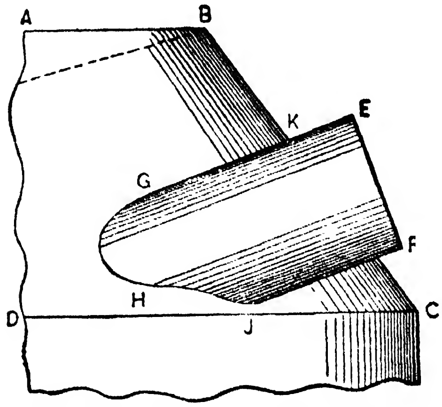


Fig. 198. Shape for which Pattern is Desired

With J in plan as center, and with the various radii shown from J O to J R, describe arcs intersecting the line E H at N^1, O^1, P^1, R^1, and S^1. At right angles to E H, and through the various intersections, draw lines intersecting the side of the cone B C in elevation at C^1, E^1, G^1, J^1, L^1. Parallel to D C, and from the intersections on B C, draw lines intersecting the center line A^1 M^1 at B^1, D^1, F^1, M^1, K^1, V^1. Then will the arcs O N^1, T O^1, V P^1, etc., represent sections of the cone in plan corresponding to the lines B^1 C^1, D^1 E^1, F^1 G^1, etc., shown in elevation.

The next step is to construct sections of the cone as it would appear if cut by the lines shown in plan by O Z, T S, U V, X W, and Y R. To avoid a confusion of lines the method has been shown separately in Fig. 200.

All that part of the plan in Fig. 199 contained in G J F has been transferred as shown by G J F in Fig. 200, the line J F of Fig. 199 being placed vertical in Fig. 200 because the sections of the cone will be taken at right angles to the line of the pipe O P. Having placed the plan in Fig. 200 in the proper position, draw any horizontal line, M^1 C representing the base of the cone in its relative position to the plan, as shown by the dotted lines. Now upon this base line M^1 C construct the half elevation of the furnace top, containing the lines representing the sections in plan, similar in all respects to A^1 B C M^1 of Fig. 199, as shown by C M^1 A^1 B in Fig. 200. For the section of the cone on the line O Z in plan, Fig. 200, proceed as follows: At right angles to the line O P in plan, and from the intersections on the arcs shown, carry lines upward, as shown by the dotted lines, intersecting lines in elevation corresponding to the arcs in plan. A line traced through the intersections thus obtained, shown from B^1 to B^2 in elevation,

will be the section of the cone if cut on the line O Z in plan. The sections on the lines S T, U V, W X and Y R in plan are obtained in the same manner as shown by the sections D^1 D^2, F^1 F^2, H^1 H^2 and K^1 K^2 in elevation, all the lines not being carried through from plan to elevation, the points of intersections only being shown, so as to avoid a confusion of lines. From the point M in plan,

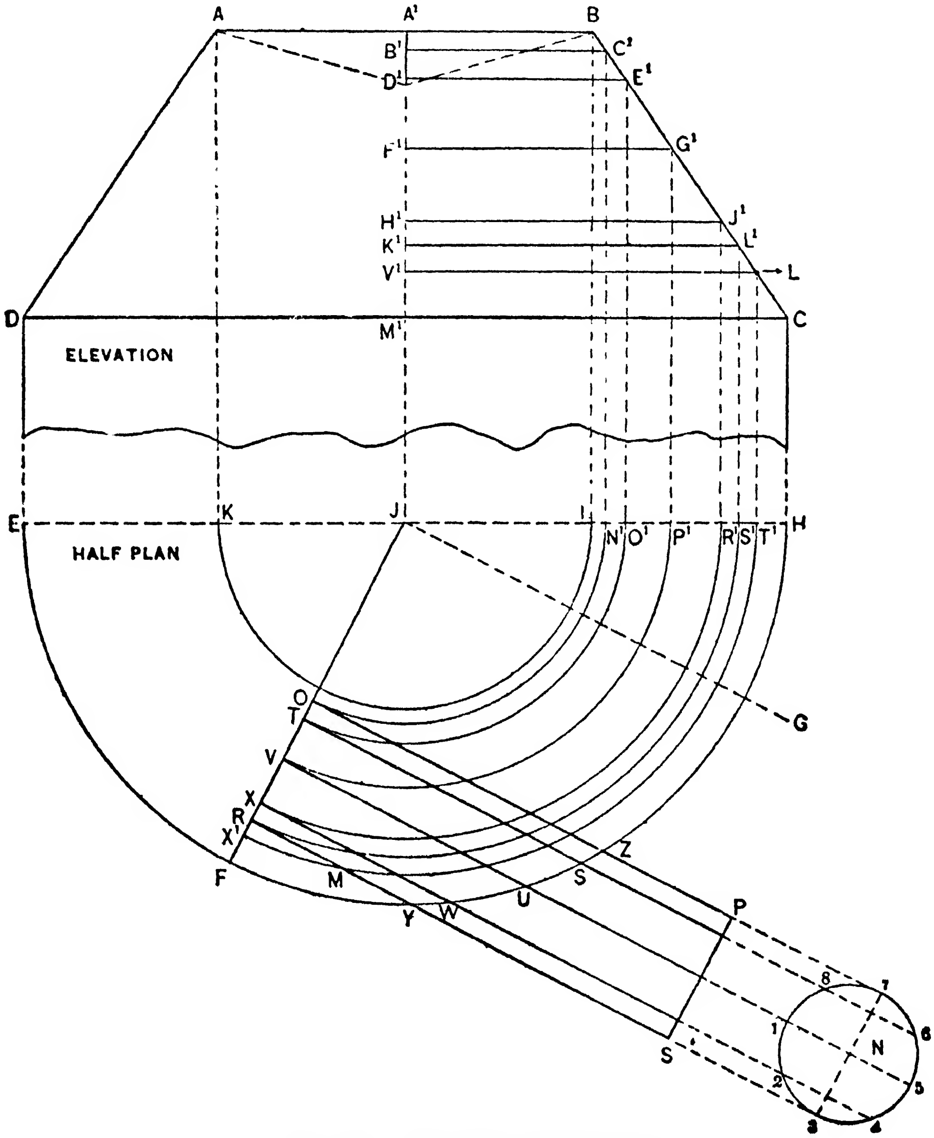


Fig. 199. Half-Plan and Elevation

Fig. 200, which indicates the position of the point 3 of the pipe, shown by H in Fig. 198, and at right angles to R S in plan, Fig. 200, draw a line intersecting the one drawn from the point L in elevation, as shown at 3. Then will 3 indicate the position of the point 3 of the pipe, shown by H in Fig. 198. Let B Q U^1 represent the angle at which the pipe is to come in elevation; then from the point

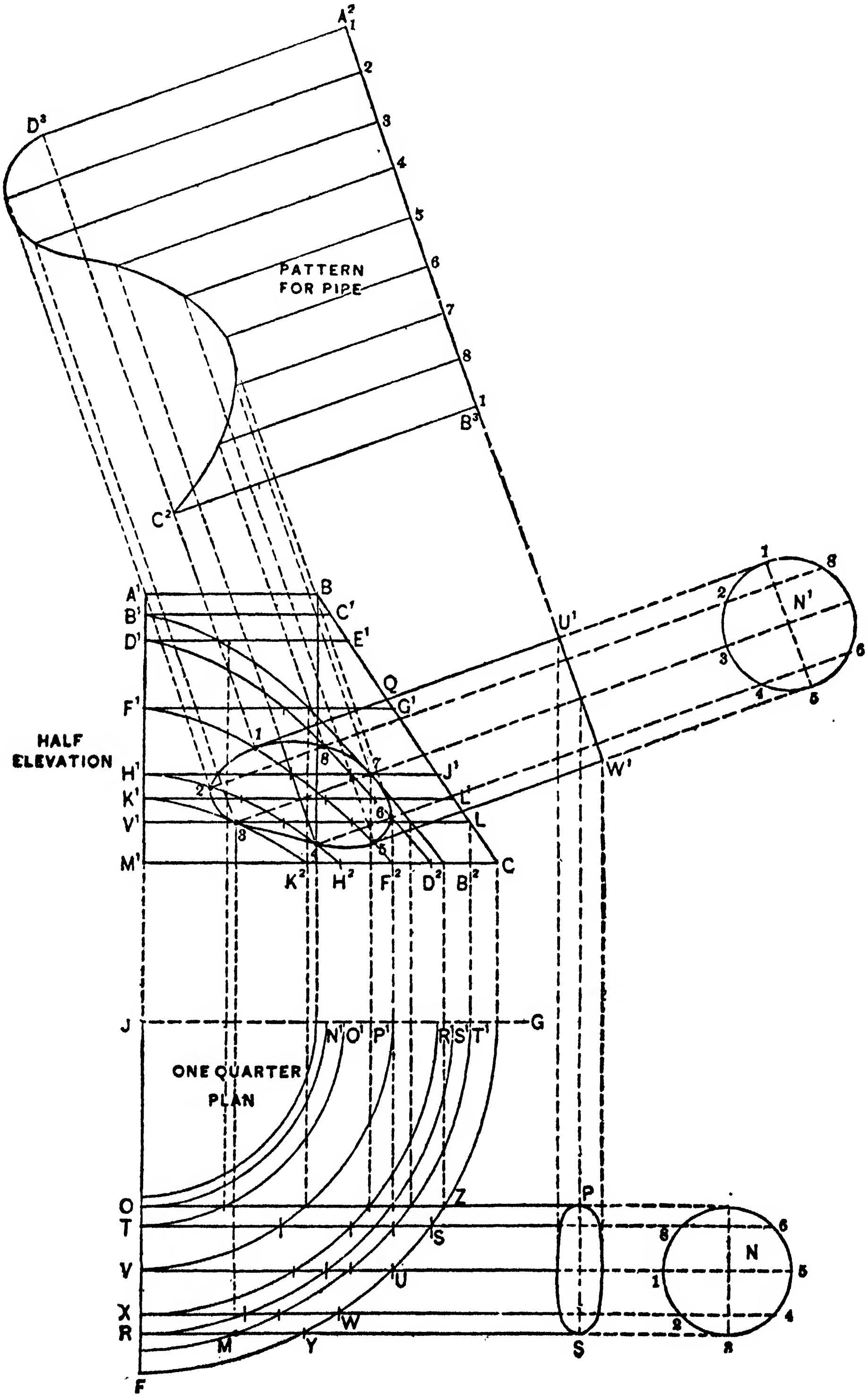


Fig. 200. Miter Line and Pattern for Pipe

3 obtained in elevation, and parallel to Q U^1, draw the dotted line 3 7. At any convenient point on the line 3 7 as center, and with radius corresponding to the profile N in plan, draw the profile N^1, as shown. As the point 1 in plan in profile N represents the top of the pipe, this point must be placed as shown at the top of the profile N^1 in elevation. Now divide the profile N^1 into the same number of equal parts as shown by the profile N.

The next step is to obtain the miter line or line of joint in elevation between the cone and pipe. By referring to the plan it will be seen that the point 7 lies in the plane of the section O Z; then must a line from point 7 in profile N^1 cut the profile B^1 B^2, which corresponds to the line O Z in plan, as shown by 7. The points 6 and 8 in the profile N in plan being in the plane of the section T S, then must the corresponding points 6 and 8 in the profile N^1 intersect the section D^1 D^2. In this manner is the balance of the points 1, 2, 3, 4 and 5 in the profile N^1 intersected with sections in elevation, as shown by the intersections 1, 2, 3, 4 and 5 in half elevation. A line traced through these points of intersections, as shown, will be the miter line, showing the intersections between the pipe and cone of the angle desired.

For the pattern for the pipe proceed as follows: At right angles to the line of the pipe Q U^1 draw the line A^2 B^3, upon which place the stretchout of the profile N^1, as shown by the small figures. At right angles to A^2 B^3, and through the small figures, draw lines, which intersect with lines of corresponding numbers drawn from the points of intersections on the miter line in elevation at right angles to Q U^1. Trace a line through the intersections thus obtained, as shown from D^3 to C^2. Then will A^2 B^3 C^2 D^3 be the pattern for the pipe mitering against the cone at the angle shown in plan and elevation. To obtain an accurate fit and the correct angle, a pattern must be obtained for the opening to be cut into the side of the cone. The method of obtaining this pattern has been shown in Fig. 201, which avoids this confusion of lines which would occur if the pattern were obtained from Fig. 200. Thus A^1 B C M^1 in Fig. 201 is a reproduction of A^1 B C M^1 in Fig. 200. Likewise the plan J G F, the pipe O P S R and profile N in Fig. 201 are a reproduction of the quarter plan J G F, etc., as shown in Fig. 200. From the points in the profile N of Fig. 201 draw horizontal lines through the plan, as shown. Now obtain a duplicate of the miter line 1 2 3 4 5 6 7 8 in elevation, Fig. 200, and place it in the same relative position, as shown by 1 2 3 4 5 6 7 8, in the half elevation, Fig. 201. Now, at right angles to M^1 C, and through the small figures in the miter line in elevation, draw lines intersecting those of similar numbers in plan, as shown by the figures 1, 2, 3, 4, 5, 6, 7, 8.

A line traced through these intersections, as shown, will be the miter line in plan showing the intersection between the pipe and cone. Through the small figures or points of intersections in the miter line in plan draw lines to the center J, prolonging them until they intersect the arc F G, as shown. Number the points of intersection with the arc G F similar to the intersections in the miter line, as shown by the small figures 2, 3, 1, 4, 8, 5, 6, 7; divide the distance shown from 7 to G into equal spaces, as shown by 9, 10, 11, etc. Extend the lines M^1 A^1 and C B in elevation until they meet at B^1. Parallel to M^1 C, and through the points or small figures in the miter line in elevation, draw lines intersecting the side of the cone B C at 8, 1, 7, 2, 6, 3, 4 and 5, as shown. Now with B^1 as center, and B^1 B and B^1 C as radii, describe the arcs B H and C G^1. From any point, as F^1, draw the line F^1 B^1, intersecting the arc B H at I. From F^1 on the arc F^1 G^1, lay off the stretchout of the quarter circle F G in plan, as shown by the small figures. From the point G^1 draw a line to the center point B^1, intersecting the arc I H at H.

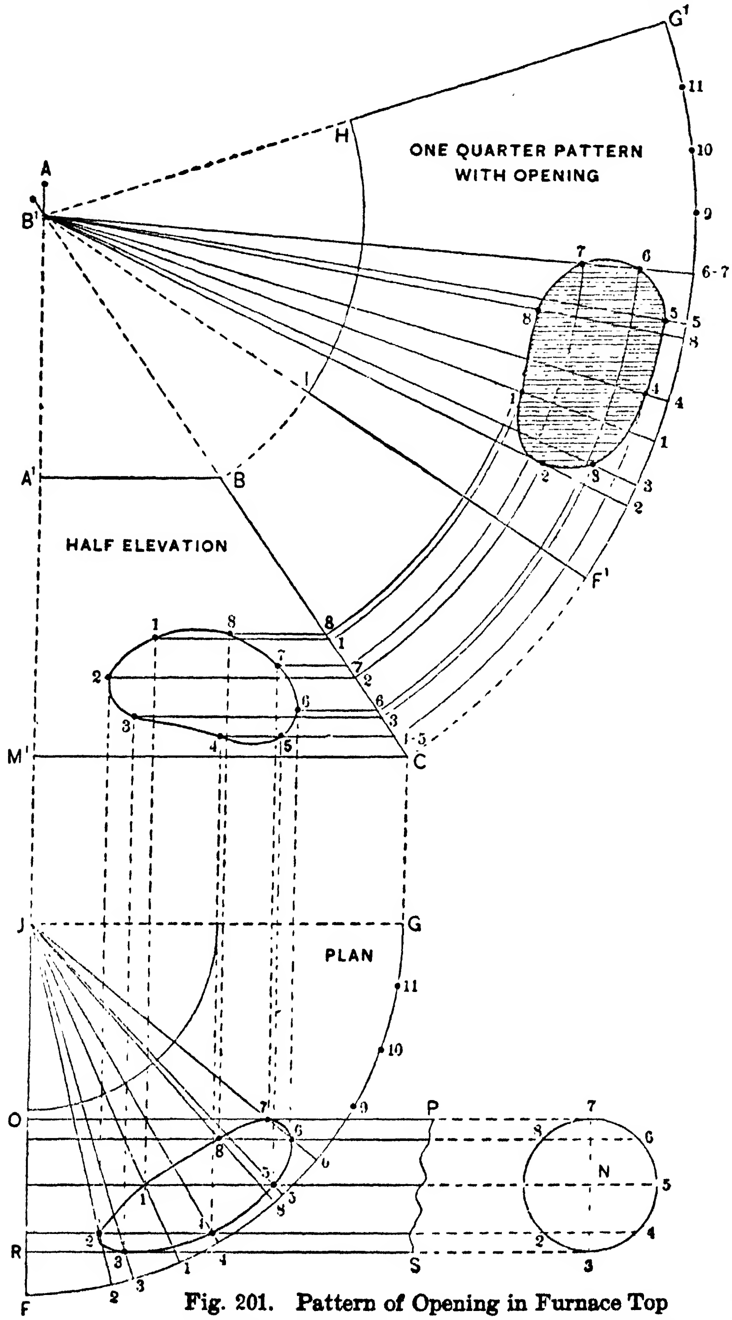


Fig. 201. Pattern of Opening in Furnace Top

From the small figures 2, 3, 1, 4, 8, 5, 6, 7 on the pattern draw lines radiating to the center point B^1. Then with B^1 as center, and B^1 8, B^1 1, B^1 7 as radii, describe arcs intersecting the radiating lines of similar numbers just drawn.

A line traced through these points of intersection, as shown by the shaded portion, will represent the shape of the opening to be cut into the side of the funnel top, of which I H F^1 G^1 represents one-quarter.

PATTERNS FOR A CONCAVE FURNACE TOP.

The concave top constitutes an inverted cone with a base 9 feet 8 inches in diameter and has an altitude 4 inches. The radius with which to describe the pattern will be the slant hight of the cone, found by constructing a diagram of the same, either full size or with accuracy to a scale not less than one-fourth full size. In the accompanying illustration Fig. 202, A C represents the vertical center line of the furnace top. Draw A B and C D horizontally 13 inches apart, representing respectively the upper and lower lines of the article. Measuring from the center line, make A B 4 feet 10 inches long, one-half the required upper diameter and make C D 5 feet 5 inches long, one-half the required lower diameter, and draw B D. Also set off on the center line the point E 4 inches below A and draw A B, thus completing a sectional view of the furnace top. Then will E B be the radius for the pattern of the concave top, as above described, the pattern being shown in the upper part of the diagram.

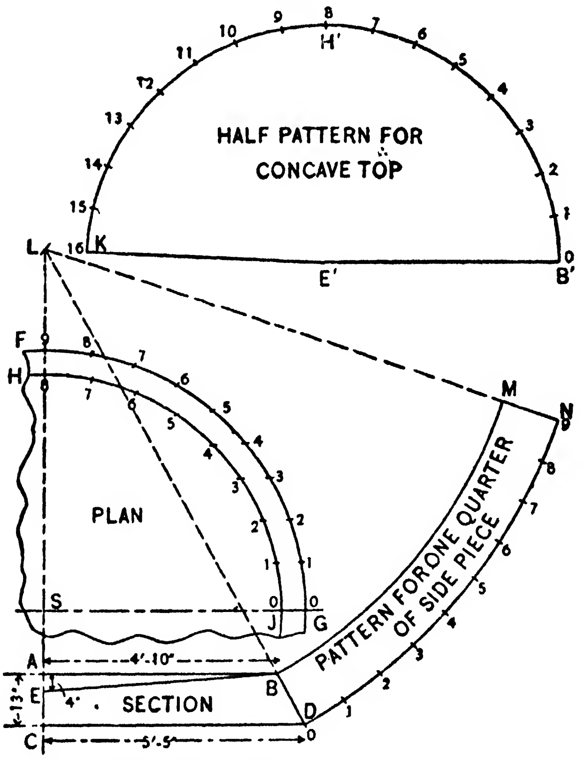


Fig. 202. Method of Obtaining Patterns.

To obtain the circumference of the pattern it will be necessary to first construct a quarter plan of the top. Therefore, from any point, as S on the center line extended, with radii equal to A B and C D, describe the quarter circles H J and F G, terminating them at the top against the center line and at the bottom, at the line S G, drawn horizontally from the point S. The circumference of the quarter circle H J, as measured by the equal spaces designated by the points 1 to 8, may then be set off on the line B′ H′ of the pattern, as shown, and if one-half the pattern should be required in one piece the arc

B′ H′ may be extended to K, making H′ K equal to B′ H′, as shown by the eight additional spaces.

To find the radius with which to describe the pattern for the sides of the furnace top, extend the line B D of the sectional view upward until it intersects with the center line A C extended at L. Then will L B and L D be respectively the radii for the upper and lower edges of the side pieces. From L as center, with these radii, describe the arcs B M and D N, as shown, and make the arc D N equal in length to the arc G F of the plan, as shown by the corresponding equal spaces in both. Then will B M N D be the pattern for one-quarter of the side piece. The necessary edges for joints should be allowed.

PATTERNS FOR RECTANGULAR FURNACE HOOD AND DEFLECTOR

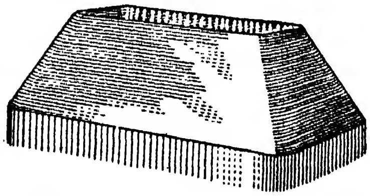


Fig. 203. Perspective View of Hood and Deflector

The problem is, where a flaring rectangular furnace hood, with rounded corners, is intersected by a flaring rectangular deflector, with rounded corners, to find the patterns for the hood and deflector, such as is shown in Fig. 203. It may be well to say that it makes no difference what size or shape this hood has, as the principles here laid down are applicable to any case.

First draw the plan of the bottom of the hood, as shown by A B C D in Fig. 204, the rounded corners being quarter circles struck from the centers *a*, *b*, *c* and *d*, as shown by *k j*, *s r*, *o n* and *m l* respectively. As the flare of the hood is be equal on all sides, and knowing the pitch, construct the plan of the top of the hood, as shown by E F G H, the corners also being quarter circles, struck from the centers *e*, *f*, *h* and *i*, with the same radii as used for the bottom, These arcs are shown respectively by *u t*, *t′ u′*, *v′ w′* and *w v*. From the plan project lines and construct the elevation, as shown by K L M N. Also draw the elevation of the deflector, as shown by M N P O, which is to have equal flare on all sides, as shown in plan by E F G H I J, the rounded corners on both ends tapering to I and J, as shown.

To obtain the patterns for the flat side and end of the hood proceed as follows: At right angles to the side and the end of the hood in plan draw the lines N^1 L^1 and N^2 L^2, equal in length to N L in elevation. Through the points N^1 and L^1 parallel to *m n* draw lines, as shown, which intersect with lines drawn at right angles to *m n* from points *w w′* and *m n*, as shown by *w″ w″* and *m″ n″*. Draw lines from *w″* to *m″* and *w″* to *n″*, and the figure obtained is the pattern for the flat side of the hood.

Through the points N^2 and L^2, parallel to $k\ l$, draw lines, as shown, which intersect with lines drawn at right angles to $k\ l$ from points $u\ v$ and $k\ l$, as shown by $u''\ v''$ and $k''\ l''$. Draw lines from u'' to k'' and v'' to l'', and the figure obtained is the pattern for the flat end of the hood.

Before obtaining the pattern for the rounded corners a diagonal elevation must be constructed from which to obtain the true section and pattern. Parallel to one of the corners in plan, as h 2, draw the line h' 2″. Divide the quarter circles $o\ n$ and $v'\ w'$, both into the same number of equal spaces, as shown by the small figures 1, 2, 3 and 1′, 2′, 3′ respectively. In practice more spaces should be employed. At right angles to h' 2″ draw the line, $h'\ h'''$, equal in hight to R N in

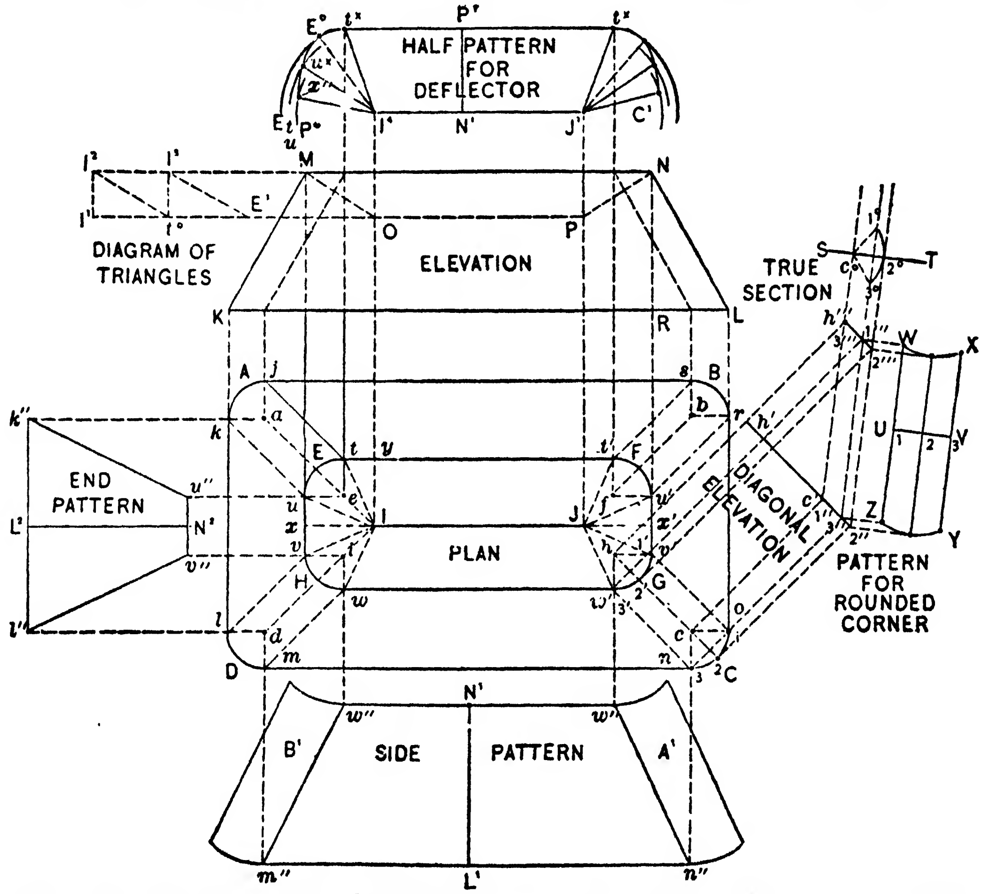


Fig. 204. Plan, Elevation, Diagonal Elevation, True Section, Diagram of Triangles and Patterns

elevation. From h''' parallel to h' 2″ draw the line h'' 2‴. At right angles to h 2 in plan, and from points c, 1, 2 and 3, erect lines intersecting the base line h' 2″ at c'', 1″, 2″ and 3″ respectively. In similar manner from h''' 2‴ at h''', 1‴, 2‴ and 3‴. Through similar numbered points on the base and top lines in diagonal elevation draw lines, as shown, extending them indefinitely beyond h''' 2‴. Then will h''', 2‴, 2″, c'' be the diagonal elevation of the rounded corner and its center.

At right angles to $c'' h'''$ draw the line S T. Measuring from the line c 2 in plan, take the distance to points 1 and 3 and place it on similar numbered lines in diagonal elevation, measuring from the line S T, thus obtaining the points c°, 1°, 2° and 3°, through which trace a line, as shown, which will be the true section of points h, $1'$, $2'$ and $3'$, of the rounded corner at right angles to the diagonal elevation. For the pattern for the rounded corner draw the line U V at right angles to $2'' 2'''$, upon which place the stretchout of the true section 1°, 2°, 3°, as shown by 1, 2, 3 on U V. Through the small figures, parallel to $2'$, $2'''$, draw lines, which intersect with lines drawn at right angles to $2''$ $2'''$ from similar numbered points on the top and bottom of the diagonal elevation. Trace a line through points thus obtained, as shown; then will W X Y Z be the pattern for the corner, which can be added to the pattern for side, as shown by A^1 and B^1.

For the pattern for the deflector, space one of the corners into an equal number of parts, as shown by t E u, and draw lines to the apex I. In practice more spaces should be used. M O in elevation represents the true length on x I and I y in plan. To obtain the true lengths on I t, I E and I u a diagram of triangles must be constructed as follows: Extend the lines N M and P O in elevation, as shown. Take the distance of I t or I u in plan, both of which are the same, and place it as shown by I^1 t° in the diagram of triangles. In similar manner take the distance I E in plan and place it as shown by t° E^1 in diagram of triangles. Erect perpendiculars I^1 I^2 and t° I^3, as shown, and draw the lines I^2 t° and I^3 E^1, which represent respectively the true lengths in plan on I t or I u and I E.

For the half pattern of the deflector take the distance of O M or P N in elevation and place it at right angles to M N, as shown by P^1 N^1. Through these two points parallel to M N draw lines, as shown, which intersect with lines drawn from points t, I, t' and J in plan at right angles to I J, thus obtaining the points t^x, I^4, t^x and J^1 in pattern. Draw lines from t^x to I^4 and t^x to J^1, which should equal I^2 t° in the diagram of triangles. With radii equal to I^2 t° and I^3 E^1 in the diagram of triangles, and with I^4 in pattern of deflector as center, describe the arcs t^x t u and E° E, recpectively, as shown. Set the dividers equal to t E and E u in plan, and, starting from the point t^x in pattern, step to similar lettered arcs, thus obtaining the intersections E° and u^x respectively. Draw a line from u^x to I^4, and trace a curve through points t^x, E° and u^x. With u x in plan as radius and u^x in pattern as center describe the arc x'', which intersect with an arc struck from I^4 as center and N^1 P^1 in pattern as radius. Draw a line from u^x to x'' to I^4. In similar manner obtain C^4 or the opposite side. Then will the outline shown represent the half pattern for the deflector in the top of the furnace hood.

PATTERNS FOR A FURNACE BOOT

Of late furnacemen are more careful to design fittings that permit the flow of air with the minimum amount possible of friction and with no reduction of area in any part of the fitting. The elevation shown in Fig. 206 is constructed in accordance with the dimensions given in the sketch, Fig. 205, but the proportions of the boot may be varied to suit any depth of joist, amount of offset or dimensions of pipes necessary to make it conform to any other set of conditions, without in the least affecting the method of developing its pattern. The reader will, of course, understand that if the proportions are varied materially from those shown in the diagrams, the results will differ correspondingly from that shown in the pattern given, but he need have no fear of error if the method herein prescribed be adhered to.

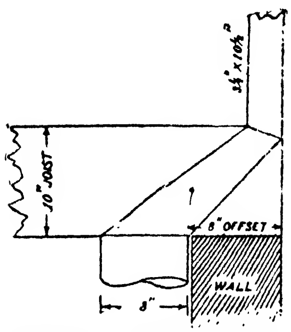


Fig. 205. Diagram of the Problem

First draw the plan with its two pipes P and Q, centered upon the horizontal line C E, placing them so that the distance D E shall equal the required offset. Next construct the elevation by projecting lines upward from each point on C E of the plan, as shown, giving B the required vertical hight above D. Some liberty may be permitted with regard to the location of point C in this view. The line C D can of course be drawn horizontally as in Fig. 205, but the function of the boot is naturally that of an elbow, and the capacity of the offset will be greatly reduced if the point C is placed on the same level with D; for it will be seen that if this is the case the distance across the boot from D to the line C B will then be much less than the diameter of the round pipe P, and further, that this narrowing will be increased as the amount of offset is increased, by reason of the increased obliquity of the lines. It is therefore necessary to elevate the point C to such a hight that the area of a section on a line, D *e*, drawn from D perpendicular to C B of the elevation, is equal to that of the round pipe P, or to that of the rectangular pipe Q, whichever may be the lesser.

It may be noted that the distance across the elevation above referred to need not be quite as great as the diameter of pipe P, from the fact that, while the distance across the boot, as seen in the side elevation, decreases from C D toward B A, the distance across, as shown by the plan, increases in the same direction, while at the same time the section is becoming more and more rectangular as B A is approached. For a like reason it will be seen that the point A of the elevation should be lowered till the line A D falls outside the point of tangency to an arc drawn from B as a center, with B *a* as radius, as shown, since the horizontal width

of the boot is decreasing from B A toward C D. These details involve no complication or difficulty in the work of developing the patterns, since the pattern for the round pipe becomes thereby the same as that for an ordinary elbow, and takes the place of a developed section on C D as a means of obtaining the true distances along the lower end of the pattern of the boot.

Having completed the plan and elevation, to develop the elbow pattern just referred to, construct a diagram of triangles by means of which to determine the true distances across the pattern of the boot from A and B to certain assumed points in the perimeter at C D, all preparatory to laying out the pattern of the boot.

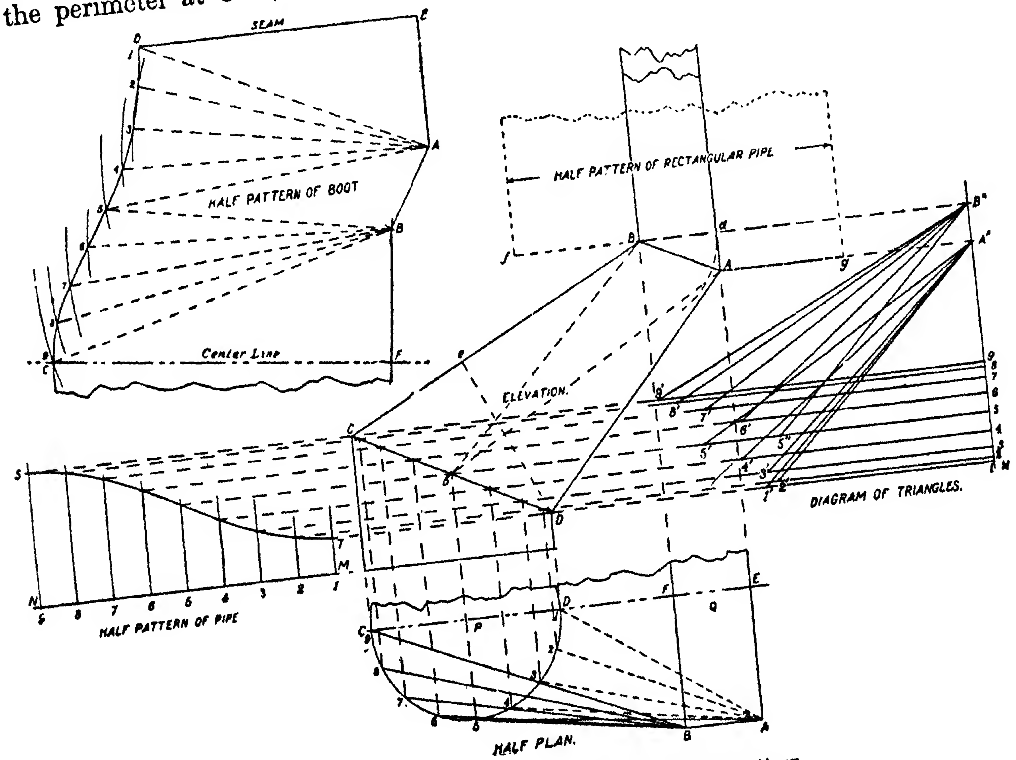


Fig. 206. Method of Laying Out Furnace Boot Pattern

First divide the profile C D of the plan into any convenient number of equal spaces, as shown by the figures, and set off the stretchout on M N, erecting the measuring lines in the usual manner. Carry lines vertically from the points in C D of the plan to cut C D of the elevation. Projections must be made from the points on C D into the measuring lines of the stretchout in developing the pattern of the straight pipe P, all as shown at the left, and also into any convenient space for constructing a diagram of triangles. The several parts of the drawing involved

have therefore been so arranged as to accomplish this result with the least possible labor. As the T square is brought successively to the several points on C D of the elevation in making the projections into the measuring lines of the stretchout, which may for convenience be placed to the left of the elevation, carry lines also in the opposite direction to cut a vertical line B′ H, erected as close as convenient to the elevation, numbering each of the horizontal lines to correspond with the point of the plan from which it was derived, as shown by the small figures above H.

Next in order will be the arrangement of the triangles the development of which will constitute the pattern for the boot. This must be done on the plan in the following manner: Connect point A with each of the points 1 to 5, inclusive, of the plan C D, and point B with the points 5 to 9, inclusive. These lines will represent the horizontal distances between the several points in the lower base C D of the boot and the points A and B in the upper end, and will form the bases of a series of right angled triangles the altitudes of which will be the distances from the several points 1 to 5, inclusive, to A′, and from 5 to 9, inclusive, to B′, as measured along the line H B′. Therefore, on each of the horizontal lines cutting H B′, set off the length of the base line of the plan of corresponding numbers; thus make the distance H (1) 1′ of the diagram of triangles equal to A 1 of the plan, 2 2′ of the diagram equal to A 2 of the plan, etc. Lines drawn from the several points, 1′ to 9′, inclusive, thus located to A′ and B′, as shown, will give the true distances from A and B of the pattern to corresponding points in its lower outline.

These measurements cover all of those portions of the pattern forming the rounded corners of the boot, each conical in shape, their bases uniting to form the elliptical opening C D and with apexes at the four points A and B. Besides these corners, there then remain four flat triangular sides, two of which are shown by B 5 A of the elevation, while the plan shows by F B C and E A D one-half each of the other two.

To lay out the pattern of the boot, first take the length along the center line of the side in which it is desired to have the seam, as D A of the elevation, and set this distance off on any straight line, as D E of the pattern, and from E draw E A at right angles to D E, making it equal in length to E A of the plan, and draw A D, which will be equal to A′ 1′ of the diagram of triangles. Now from A of the pattern as center, with radii equal to A′ 2′, A′ 3′, A′ 4′ and A′ 5′ draw the several arcs shown in the pattern between D and 5 giving to each its proper number. As intimated above, the measurement along the lower side line of the pattern of the boot must be equal to that along the upper side of the

pattern of the pipe; therefore set the dividers to the first space (1 to 2) on T S, and placing one foot of the dividers at D or 1 of the pattern, swing the other foot around to cut arc 2 just drawn in the pattern, thus locating the point 2 of the pattern. Now from 2 as center with a radius equal to 2 3 of the line T S describe an arc cutting arc 3 of pattern locating point 3. As A′ 2′ and A′ 3′ of the diagram of triangles are in this case equal, one arc answers for both in the pattern. This operation is continued to complete the lower outline of the pattern, stepping from one arc to the next in order and making the several spaces from D to C of the pattern, respectively, equal to those along T S of the other pattern. When the point 5 of the pattern of the boot has been reached, take the distance 5″ B′ of the diagram of triangles as a radius and from 5 of the pattern as center describe an arc, which, cut with another struck from A of the pattern as center with a radius equal to B A of the elevation. The intersection of the two arcs will locate the point B of the pattern, which becomes a center from which to describe those arcs between 5 and C of the pattern the radii of which are respectively equal, to B′ 6′, B′ 7′, B′ 8′ and B′ 9′. It remains now only to add the triangular space shown by F B C of the plan, the true central measurement of which is shown by B C of the elevation. Therefore, with this distance as a radius and C of the pattern as center, describe an arc which intersect with another arc struck from B of the pattern as center, with a radius equal to B F of the plan. This completes the half pattern. If it is desired to make the entire pattern in one piece, describe an arc from C as center with C B as radius, and intersect the same with an arc drawn from B as center with a radius equal to two times B F. This will locate point B on the opposite side of the pattern not shown in the illustration. If it is desired to obtain the entire pattern in one piece by development it may be most economically accomplished by first laying out this last named triangle (B C B) then conducting the work in a reverse order to that above described, working from C toward D and carrying both sides along together. Other methods of duplication may, however, be deemed more expedient.

The pattern for the rectangular pipe above is of so simple a nature as scarcely to require explanation. One-half of it corresponding to F B A E of the plan is shown in dotted lines in the upper part of the engraving, in which *f* B A *g* shows its mitered end.

PATTERN FOR OFFSET BOOT, ROUND TO OVAL

A view of a finished offset boot such as would be used in heating and ventilating piping is shown in Fig. 207. The development of the top and bottom pipes

of the boot is done by the usual method, but the pattern for the center piece will be obtained by triangulation without using the plan for obtaining the basis of the sections and without finding the true sections on the miter lines 1′ 5′ and 6′ 10′ in Fig. 208, as is usually done.

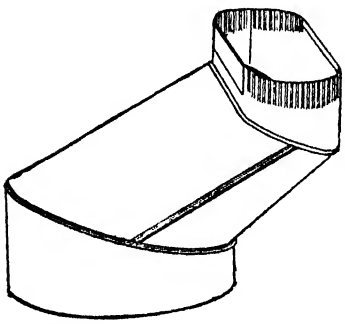


Fig. 207. View of Finished Offset Boot.

Draw the elevation of the boot, as shown by A B C D, establishing at pleasure the miter lines 1′ 5′ and 6′ 10′. Below the elevation the plan view F E 10 is drawn, which, however, is not necessary, it only being here shown to indicate that the halves of the boot on both sides of the line *c d* are symmetrical. Place the profile of the round pipe below D C and divide it into equal spaces, as shown, from 6 to 10 on both sides. In similar manner place the profile of the oblong pipe above A B, and also divide the semicircles at the ends into the same number of spaces as the semicircles below C D, as shown from 1 to 5 in the oblong profile, and through the center of which draw the line *a b*. From the various intersections in the round and oblong profiles draw vertical lines intersecting the miter lines 6′ 10′ and 1′ 5′, respectively, as shown.

Take the stretchout of the round pipe and place it on the horizontal line C H, as shown. Draw the usual measuring lines, which intersect by lines drawn from the various intersections 6′ to 10′ parallel to C H, resulting in the intersections 6″ to 10″ to 6″. C I J H is then the pattern for the round pipe.

The pattern for the oblong pipe is obtained by taking the stretchout of the oblong pipe and placing it on B K and proceeding as before. B L M K is the desired pattern. Bisect 1 1 in the pattern P and obtain *e*, which will be used in developing the center piece. From the various intersections on the miter lines connect lines, as shown, from 1′ to 9′ to 2′ to 8′ to 3′ to 7′ to 4′ to 6′. These lines represent the bases of sections which will be constructed, with altitudes shown in the two profiles of the pipes. For example, to find the true length of 2′ 9′ in elevation, take this distance and place it as shown by 9 2 in the diagram of sections. From 9 and 2 erect the altitudes 9 9′ and 2 2′, equal respectively to the distances measured from the line *c d* in plan to the point 9 and from the line *a b* in the oblong profile to the point 2. The distance from 2′ to 9′ in R is the desired length. In this manner all of the true lengths shown in R are obtained.

The pattern for the transition piece is developed as follows: Assuming that the seam is to come on 5′ 6′ in elevation, take the distance of 1′ 10′ and place it as show by *e* 10 in Fig. 209. With *e* 1 in the pattern P, in Fig. 208, as radius, and *e* in Fig. 209, as center, describe the arc 1, which intersect by an arc struck from 10

as center and 10 1′ in the diagram R in Fig. 208 as radius. With 10″ 9″ in the pattern O as radius, and with 10 in Fig. 209 as center, describe the arc 9, which intersect by an arc struck from 1 as center and 1′ 9′ in the diagram R in Fig. 208 as radius.

With 1″ 2″ in the pattern P as radius, and 1 in Fig. 209 as center, describe the arc 2, which intersect by an arc struck from 9 as center and 9′ 2′ in diagram R in Fig. 208 as radius. Proceed in this manner: Using alternately first the divisions

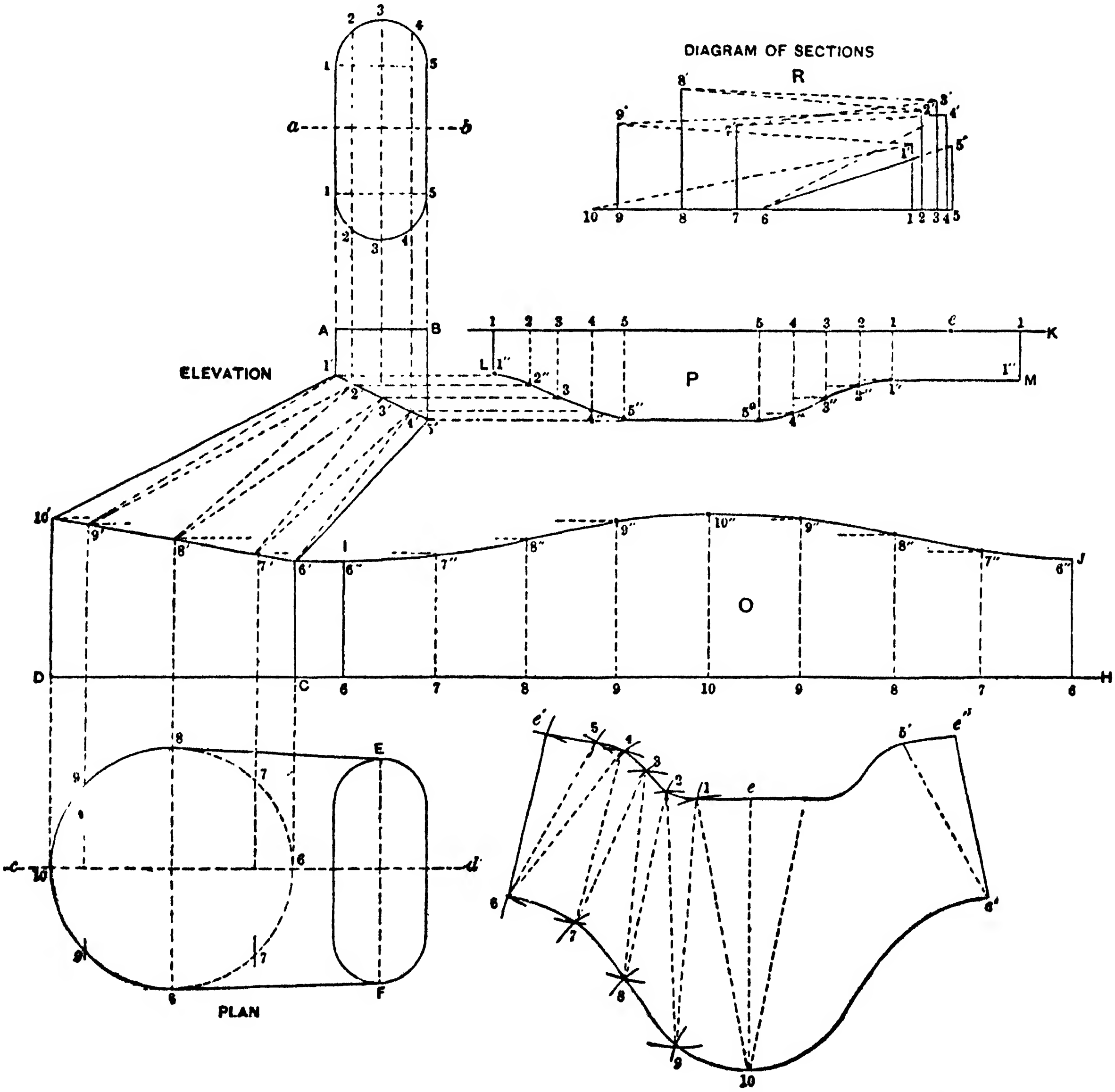


Fig. 208. Plan, Elevation, Diagram of Sections and Patterns   Fig. 209. Pattern for Transition Piece

along the miter, cut I J in the pattern O, then the true length in R; the divisions along the miter cut L M in the pattern P, and again the proper length in R, until

the line 5 6 in Fig. 209 has been obtained. Then 5 e' and e' 6 represent respectively the lengths in Fig. 208 shown by e 1 in the pattern P and 5′ 6′ in elevation. Allowance must be made in the pattern for seaming.

PATTERNS FOR STOVE PIPE CONNECTION

The subjoined article is in answer to a request for patterns for an interesting stove pipe elbow. The stipulation was that the stove be connected with the fireboard and, if possible, that the connection should have a flat place where it leaves the stove, so it could be used for a variety of purposes. At the fireplace the thimble is 6 in. and the collar on the top of the stove is equivalent to a 6-in. pipe flattened out to an oval.

In Fig. 210 is presented a reproduction of the sketch as submitted, in which all conditions and dimensions are carefully shown, with the exception that details are omitted from that part of the pipe immediately connected with the stove and for which the patterns are desired. The problem presented therein contains conditions somewhat novel even in the line of sheet metal work. The part in question, the horizontal portion, must be so constructed as to form a joint at one end (the right in Fig. 210) with a short piece of pipe, the profile of which is that of the collar on the stove, while its other end must form a joint or miter with the round pipe which descends obliquely at the back of the stove. Such pieces are by no means uncommon, but the general shape is that which naturally results from the transition from one profile to the other.

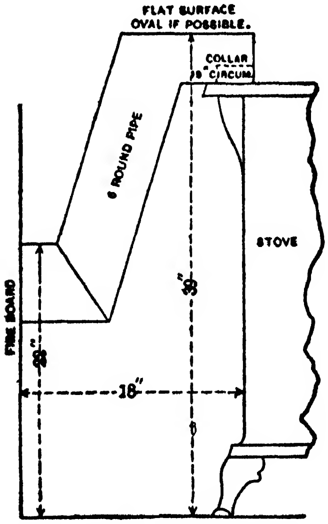


Fig. 210. Stove Pipe Connection as Desired

It is specified that the top surface of this section of the pipe shall be flat and (referring now to the legend on the drawing, Fig. 210) oval if possible. One may pause for a moment to remark that it seems to be a universal error to use the word "oval" when "elliptical" is meant. An ellipse is a symmetrical figure—that is, when divided by either its longer or its shorter diameter both halves are exactly the same, which is not true of the oval when divided by its shorter diameter. In other words, the word "oval" signifies egg shaped. It is presumed, however, that the simplest method of solution which will give the desired flat surface on top will be

satisfactory without reference to its exact shape. It is therefore shown how the given shapes of the several parts may be utilized to produce the nearest approximation to an "oval" top which they are capable of, maintaining at the same time a uniform capacity throughout the course of the pipe so far as possible.

Begin the work by the construction of a plan and an elevation of the several parts of the pipe as shown in Fig. 211, which is drawn to a scale of 2 in. to the foot. Working drawings must, of course, be made full size, so that the patterns when obtained can be transferred at once to the metal and cut. The general outlines of these two views as given in Fig. 211 can therefore be redrawn full sizes—that is, each dimension multiplied by six—after which the subsequent operations can be conducted as explained herein.

In beginning the drawings, the hight B C should be somewhat more than the width across the collar at its widest part, plus the hight of the collar above the stove, so that the capacity of the elbow may not be reduced in the least. From B draw B A horizontally to meet the outer line of the inclined pipe at A. Before going further with the elevation, begin a plan by carrying the points A, B and D upward to cut a center line drawn horizontally, as shown at A′, B′ and D′. Now bisect D′ B′, draw the vertical center line G H of the collar and complete the plan or profile of the collar, which becomes the profile of the vertical pipe E D C B of the elevation. This profile must, of course, be made to correspond exactly with that upon the stove. In Fig. 211 it has, for simplicity, been made to consist of two semicircles the centers of which are at *c* and *d*, joined by straight lines. In many cases the sides of the profile are somewhat curved instead of straight.

In providing for the required flat surface on the top of the pipe, the line A B of the elevation can be assumed as an edge view of such surface, while its outline or shape must be determined upon the plan. To assist in this operation, suppose for the time being that the inclined portion of the pipe is continued up to intersect with the plane A B, as shown at the points A and *e*. Since now the plane represented by the line A *e* is oblique to the sides of the pipe, A K and F L, a section through the pipe on this line will be an ellipse with a major axis A *e* and minor axis equal to the diameter of the pipe as shown in the profile below. This ellipse if represented upon the plan would pass through the points A′ and *e*′. In consideration of the fact that, in the present case, the line A *e* is a very little greater than the diameter of the pipe and that only a portion of the section will be used, it will answer all purposes to set off from A′, on A′ B′ of the plan, a distance equal to the radius of profile S, as shown at *f*, and from *f* as a center draw somewhat more than half a circle, as shown. Lines drawn tangent to the circle

just drawn and to the circles the centers of which are at c and d, all as shown by a'' H and a' G, will complete the outlines of what may be made a flat surface. To the several curves and sides of this surface patterns to form a satisfactory elbow can be made to meet without difficulty.

The surface A′ a'' H B′ G a', while neither an ellipse nor an oval, more nearly approximates the latter. Two other methods of solving the problem are possible. By one method the flat service on top can be made a true ellipse, or even a figure of any shape, while by the other method the shape will be that of the common approximation to an ellipse consisting of arcs of circles; but both methods will be more complicated than that herein shown. As the shape just obtained in Fig. 211 includes the entire space within the outlines of the plan, which an ellipse would not, it is presumed that the shape there shown will be more acceptable than if the letter of the request had been complied with, because of the greater area thus obtained. Therefore, it will be shown how the remaining parts of the elbow may be laid out.

From points a' and b' of the plan, drop lines cutting A B of the elevation as shown at a and b. Since the point E has already been fixed as the throat of this part of the elbow, draw a line from E to b, constituting the miter line between that part of the pipe which fits over the stove collar and the intermediate or transitional piece. In locating the point F, the throat of the second elbow, it is necessary to place it just low enough that the area of a vertical section through the pipe at F g'', and indicated by g g' of the plan, is equal to that of the round pipe; at least it should be no smaller than that of the smallest part of the pipe, which is in reality at the collar of the stove. This is simply a matter of figures. If it is assumed that 5 in. is a proper distance below the line A B to place the point F, it can be seen by comparison that the area of the vertical section above mentioned is about equal to that of the profile of the round pipe. In the diagram in the lower left hand corner of Fig. 211, F g g' is a section on F g' of the plan and elevation, while the circle is the same as that of the profile S. Therefore draw F a, representing the miter line of the second elbow, and F E, the bottom line of the transitional piece, thus completing the elevation.

For the pattern of the inclined pipe, first divide its profile, S, into any convenient number of equal spaces, as shown by the small figures, and from the points thus obtained project lines parallel to A K to cut the lines A a and a F as shown. Since both halves of the pattern will be the same, one half of the profile may be used for both halves of the pattern. Inasmuch as neither of the points in the profile strikes the point a, the intersection of the two miter planes, this point a

must be carried back to the profile as shown, where it is also marked *a*. The several spaces in the profile must now be set off on any straight line, as M N, drawn at right angles to the lines of the pipe and numbered accordingly, thus constituting what is termed a stretchout of the profile, one half of which only is shown in the drawing. From the several points on M N measuring lines are drawn parallel to A K, extending somewhat beyond a point opposite the miter to be made. Now from each of the points previously obtained on the miter lines project lines at right angles to A K, to cut measuring lines of corresponding number. A line traced through the points of intersection will give the required pattern, one half of which is shown by Q R P.

The method of developing the pattern for the vertical pipe is exactly similar to that just described. One half of its profile is shown by D′ G B′, the curved portion of which is divided into equal spaces, and the entire stretchout should be set off on the line A B of the elevation extended and numbered correspondingly, one half as before being shown. Only a portion of this profile miters against the oblique plane E *b*, and, as before, the point *b*′ must be carried back into the profile and properly located in the stretchout, as shown by *b*′. A portion only of the points is included in the miter, the remainder being required to obtain the exact length of the stretchout. The projection of the points from the plan against the miter plane E *b* and thence into the stretchout is clearly shown.

The pattern for the intermediate section of the elbow, which, it will be observed, is irregular in shape, is obtained by triangulation, which consists in dividing its surface into triangles and then obtaining the true lengths of the several sides of each by a system of diagrams. In these operations it will be convenient to use the points along the two miter lines F *a* and E *b*, obtained in developing the previous patterns. With this part of the work in view, therefore, the profiles S and D′ G B′ should be so divided at the outset that those portions of the two miters which are to be connected by the transition piece shall each contain the same number of spaces. Thus in one half of the miter, F *a*, there are five spaces, which is also true of the miter E *b*, remembering that the point D′ is exactly behind the point 8, as shown upon the plan. The method of procedure is to first connect points of like number in the two miters by a system of lines, and then to divide the four-sided figures thus produced by another system of lines diagonally, the latter system being dotted simply for distinction, thus cutting the entire surface of the part to be developed into small triangles. The triangulation may be indicated either upon the plan or the elevation, according to the nature of the subject. It is sometimes advisable to show it upon both views, in order to determine which view will best

serve the purpose of obtaining subsequent measurements. In the present instance the plan is used for this purpose.

Before beginning this work, however, it will be necessary to obtain a view of the miter *a* F in the plan. This can be accomplished in the following manner: Project lines from all the numbered points in *a F* vertically into the plan, cutting the center line A′ B′, as shown, between *f* and F′, and on each vertical line set off from the center line the length of lines of corresponding number in the profile

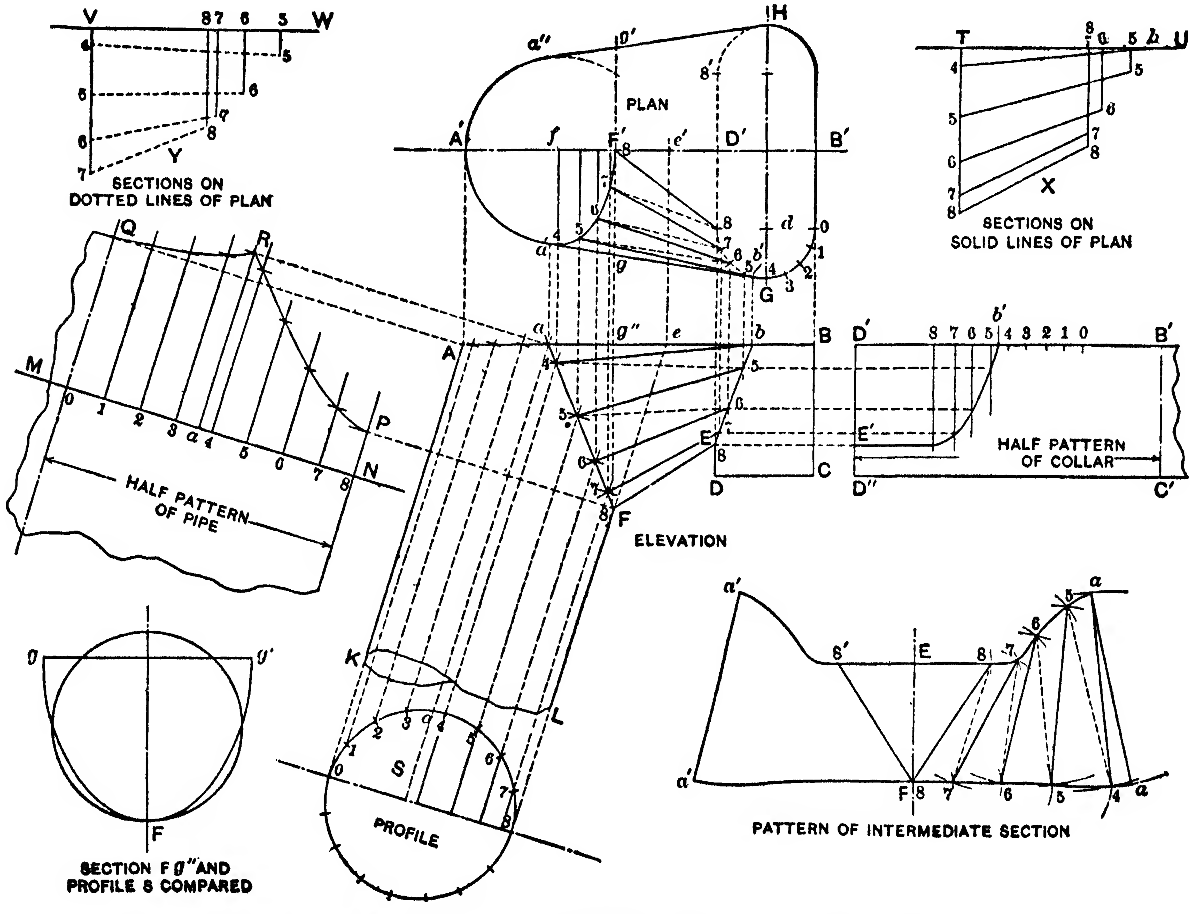


Fig. 211. Design for Elbow and Method of Developing Patterns for It

S as measured from its center. A line traced through the points of intersection, as shown from *a*′ to F′ of the plan, will give the required view. Now connect points of corresponding numbers in the two miters by solid lines, as shown by 8 8, 7 7, etc., and draw dotted lines connecting diagonally opposite points, so as to obtain the shorter diagonal. Thus a line connecting 7 of the miter *a*′ F′ with 8 of the plan of the collar is shorter than a line drawn from 8 at the left to 7 at the collar. Follow the same order throughout the piece, connecting 6 with 7, 5 with 6, etc.,

as shown. Had the side lines of the stove collar been drawn curved, as mentioned before, it would be necessary to add one or two more points in this curve between 8 and D′, from which solid lines could have been drawn to point F′ of the other miter. In obtaining the true lengths of the several solid and dotted lines of the plan, it will be seen that the horizontal distance between any two connected points can be measured upon the plan, while the difference in vertical distance between the same two points can be obtained from the elevation.

Therefore, to obtain the true lengths of the solid lines of the plan, construct the diagram shown in the upper right hand corner of Fig. 211, marked X. First set off their several lengths from T on the horizontal line T U, as shown by the small figures near U. From T and from each of the numbered points drop vertical lines, as shown. Upon the line from T set off the hights of the numbered points in *a* F as measured vertically to the line A B, numbering each point correspondingly. Upon each of the other vertical lines near U set off the vertical hight of the point of corresponding number in E *b*. Now connect points thus obtained with points of corresponding number on line T. The several lines, 4 *b*, 5 5, etc., will then represent the true lengths of the corresponding lines of the plan of elevation.

The true lengths of the dotted lines of the plan are obtained in exactly the same manner, all as shown by diagram Y at the left. Having now obtained the true lengths of all the long sides of the triangles, find the lengths of their short sides or bases in the edges of the two miter patterns first obtained. Thus the true distances, *a* to 4, 4 to 5, etc., of the left end of the pattern of the transition piece are found between R and P of the pattern of the oblique pipe, while the true lengths of the spaces *b* to 5, 5 to 6, etc., for the end adjoining the collar are found between E′ and *b*′ in the pattern for the collar piece.

It simply remains now to construct the several triangles indicated upon the plan one after another in their proper sequence. Therefore, the work can be begun most advantageously by constructing the triangle indicated by 8 F′ 8 of the plan, viz: Upon any line as a center line, as F E below the elevation, set off the length F E of the elevation, and through the point E draw a line at right angles, upon which set off in either direction from E the distance D′ 8 of the plan, as shown by 8′ and 8, and draw the lines F 8 and F 8′. The same result may be obtained by first drawing the line 8′ 8, making it equal to 8′ 8 of the plan; then with the distance 8 8 of the diagram X as radius and the points 8′ and 8 of the pattern as centers, strike two arcs, intersecting at F. Proceed now to add to one side of this the triangle indicated by F′ 7 8 of the plan, viz: With the distance 8 7 of the diagram Y as a radius and the point 8 in the upper edge of the pattern as center,

strike a short arc near F, which intersect with another arc struck from F as center, with a radius F′ 7 of the miter pattern of the oblique pipe, thus establishing the point 7 in the lower side of the pattern. Now, with 7 7 of diagram X as radius, and point 7 of pattern just obtained as center, strike a short arc, which intersect with another arc, its center being 8 in the upper side of the pattern, and its radius is the distance 8 7 of the miter pattern of the pipe to fit the collar, thus establishing the point 7 in the upper side of the pattern. Proceed in this manner, using as radii the distances obtained in diagram Y in connection with those on the edge of the pattern of the oblique pipe in obtaining the points along the lower side of the pattern, and the distances in diagram X with the spaces on the edge of the pattern of the collar piece in obtaining the points in the upper edge of the pattern, until all the distances have been used and the line *a a* is reached, which will complete one half the pattern. That part of the pattern shown by *a* 8 8 *a* can be transferred by any convenient means to a reverse position at the left of the first large triangle, thus completing the entire pattern. It is understood that the necessary edges or laps required to make the usual form of joints must be added to all of the patterns; the pattern here shown being net.

RISES FOR ELBOWS

The rise in an elbow is equal to the difference in length between the longest side and the shortest side of an end piece. In the accompanying illustration, Fig. 212, showing a three-piece elbow, the distance A B is the rise. The following are the rises of elbows of from 3 to 10 pieces, the diameters of which are 1 inch:

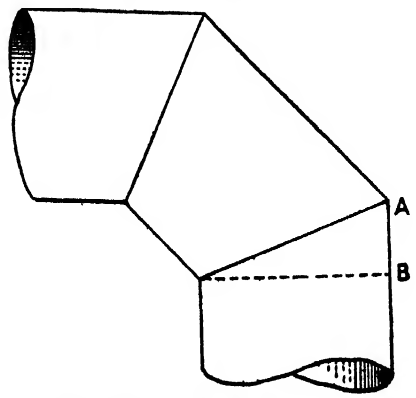


Fig. 212. Rises for Elbows

8 piece elbow,	0.414	inch rise		7 piece elbow,	0.132	inch rise
4 " "	0.268	" "		8 " "	0.113	" "
5 " "	0.199	" "		9 " "	0.098	" "
6 " "	0.158	" "		10 " "	0.087	" "

FRACTIONAL EQUIVALENTS (Correct to 1-64 of an Inch)

0.414	13-32	0.132	9-64
0.268	17-64	0.113	7-64
0.199	3-16	0.098	3-32
0.158	5-32	0.087	5-64

To find the rise for an elbow of any diameter multiply the rise given in the above table by the diameter in inches of the desired elbow, and the result will be the rise in inches for the desired elbow. Thus, to find the rise for a seven-piece

elbow the diameter of which is 11 inches, multiply 0.132 by 11, which will give 1.452 inches, the desired rise.

THE PERFECT ELBOW PATTERN

All tin and sheet iron workers who have had experience in making elbows for round pipe know the trouble there is in trimming the pieces for the elbows, especially if they have a quantity to put together. Even a miter pattern developed by a system of lines in the ordinary way needs to be trimmed to meet the requirement of a seam. A perfect pattern requires that proper allowance shall be made for the "take up of the seam," as it is called.

The object of the diagrams, Fig. 213, and the accompanying explanations, is to show how a correct and reliable pattern can be obtained that will require no trimming of the work afterward. Solid lines in Fig. 213 show profile of a square elbow. A B is the miter or angle line of the profile. The dotted lines A C and A D show the correct miter line required in an elbow with the usual seamed joint. To determine the points C and D first extend the line E B sufficiently to make the distance from B to C 1-16 inch longer than the width of seam required, as the seam naturally works a little large. The seam for this purpose being usually made in the small, thick edge machine, set the gauge the required width for the seam, from ⅛ to 3-16 inch, as the case may be. If the seam is ⅛ inch wide then make the distance from B to C 1-16 inch more, or 3-16 inch; if the gauge is set for a seam 3-16 inch wide, then make the distance from B to C, ¼ inch. The distance from B to D on line B E is always the same as the distance from B to C. This is what would be termed adjusting the miter line to meet the requirements of the seam. Having established these miter lines A C and A D, proceed to develop a pattern from them the same way as from the miter line A B of the profile.

On the plan of the pipe, as shown, space off on the circle 1, 2, 3, etc., up to 9, as in this case, equal to one half the circle or size of pipe. From these points 1, 2, 3, etc., and at right angle with the base line E F, draw lines to intersect with miter lines A C and A D. Then draw a line, as K L, shown to the left, level with the base line E F. On this stretchout line K L space off the distance 1, 2, 3, etc., up to 9, the same as in the plan, then duplicate the numbers, except 9, and this gives the stretchout or circumference of the pipe. From these points 1, 2, 3, etc., on line K L, and at right angles with it, draw lines of sufficient length to intersect lines drawn at right angles with these lines from corresponding points 1, 2, 3, etc.,

on miter line A C and A D. The intersecting points of these lines, after connecting them, give the miter lines, *a d* and *e h*, that are required, all as shown in the diagram, Fig. 213.

a b c d is the developed pattern for that half of the elbow represented by A F E D. The developed pattern, *e f g h* , is for that half of the elbow represented by A F E C. The end lines of the pattern, 1 at *c* and 1 at *b*, are to be of sufficient length to form the width of pattern required usually calculated to cut from stock material without waste. In order to have a guide to go by in putting the two pieces together, to make the elbow true and free from twist or wind, make a prick mark in the center of the pattern *e f g h* about ½ inch from the miter line, as shown by *k*. Then, when putting the pieces together, place this dotted point, as shown by *k*, exactly in line with the seam of the opposite piece, if the seam is a lapped seam—that is if the horizontal seam of the pipe is a lapped seam. But if the seam (horizontal) of the pipe is a locked or grooved seam, then place this dotted point in line with the center of the seam, which varies in width from ¼ to ½ inch, more or less.

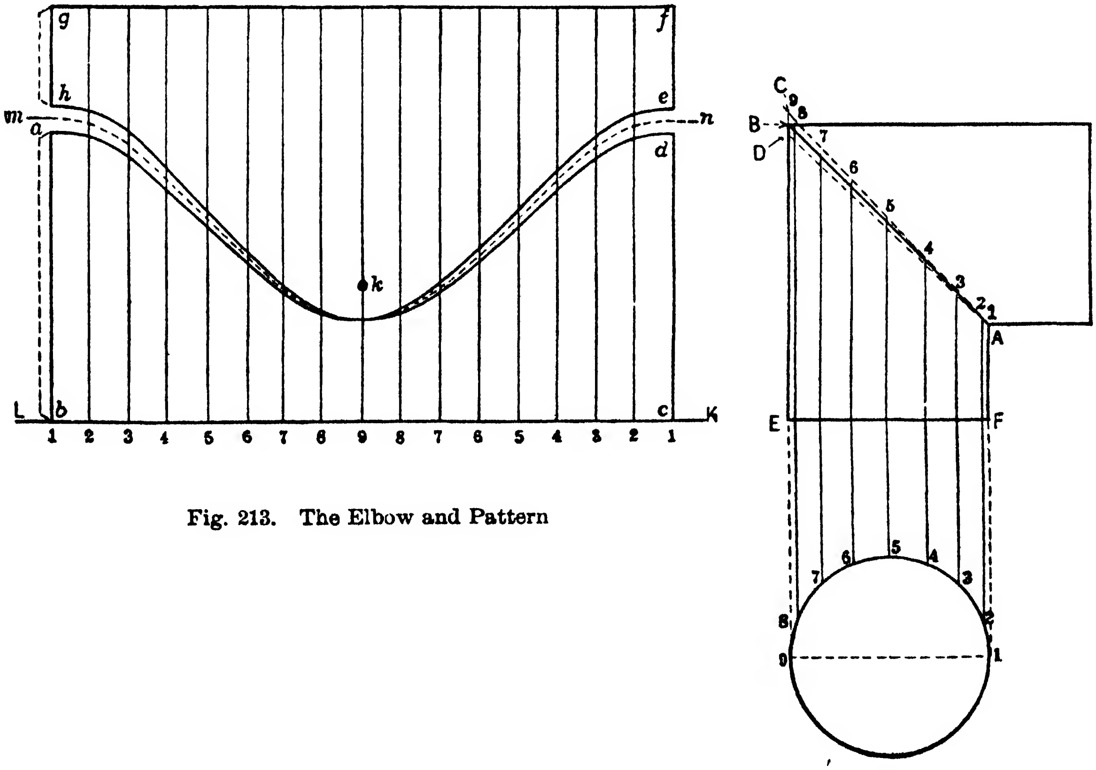


Fig. 213. The Elbow and Pattern

This method of securing a perfect pattern applies alike to elbows made to any angle or bevel, as the same width of seam, or lock, is used in both cases of square and beveled miters. If the pipe is to have simply a lapped joint, one piece lap-

ping over the other, then add the width of lap at one end of the developed pattern as shown to the left of the pattern in Fig. 213.

If it is to be a seam that has edges turned and grooved together, then divide the lap required for making the seam equally between each end of the pattern. The dotted line *m n* between the solid miter lines *a d* and *e h*, shows the developed pattern from miter line A B in the profile. It also shows what has to be cut away to meet the requirements of the seam when such a pattern development is used.

SEAMS IN AIR DUCTS

A popular method of seaming elbows and rectangular pipes is by use of what is often termed the "Pittsburg" seam. A section of an elbow taken on the line A B of Fig. 214 is as shown in Fig. 215 with the seam exaggerated in size. The sides or cheeks of the elbow have a ¼-in. edge allowed, which is bent out square, usually with a mallet and dolly, and would be as shown in Fig. 216. The back and throat of the elbow have ⅞ in. allowed and are bent as shown in Fig. 217.

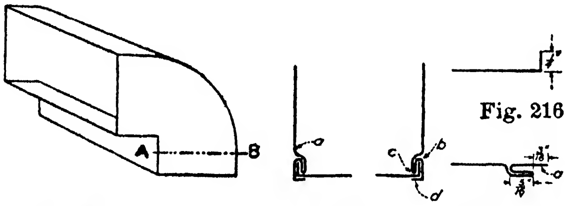


Fig. 214 Fig. 215 Fig. 217

Details of Making a "Pittsburg" Seam

This pocket edge is placed on the back and throat because it would be impossible to form it on the circular part of the sides—whereas on the back it is bent in the brake, while the back is flat and then rolled to shape. During the rolling operation a heavy strip of metal is placed in the pocket so that the rolls will not squeeze the pocket tight. The edge of the side is slipped into this pocket when assembling the elbow and to keep it in the pocket the upstanding edge *a* of Fig. 217 is hammered over as at *d* in Fig. 215. The idea of the shoulder or depression *a* in Fig. 215 is to have a foundation for the impact of the blows of the hammer during the operation of throwing over the edge. Without this a dolly would have to be held on the edge *b*, Fig. 215, to prevent driving it back and distorting at *c*. This depression also makes the pocket seam flush with the outside of the cheek and almost invisible. As no other tools for assembling are required, this seam is commendable in case piping must be shipped in parts from the shop to the building.

THREE PIECE ELBOW OVAL TO ROUND

The exemplification of this problem, is by what the author terms a simplified process, dealing with triangulated articles that have two symmetrical halves.

Referring to Fig. 218, first draw the side elevation of the elbow of the required size and angle and in its proper position outside of the top and bottom openings

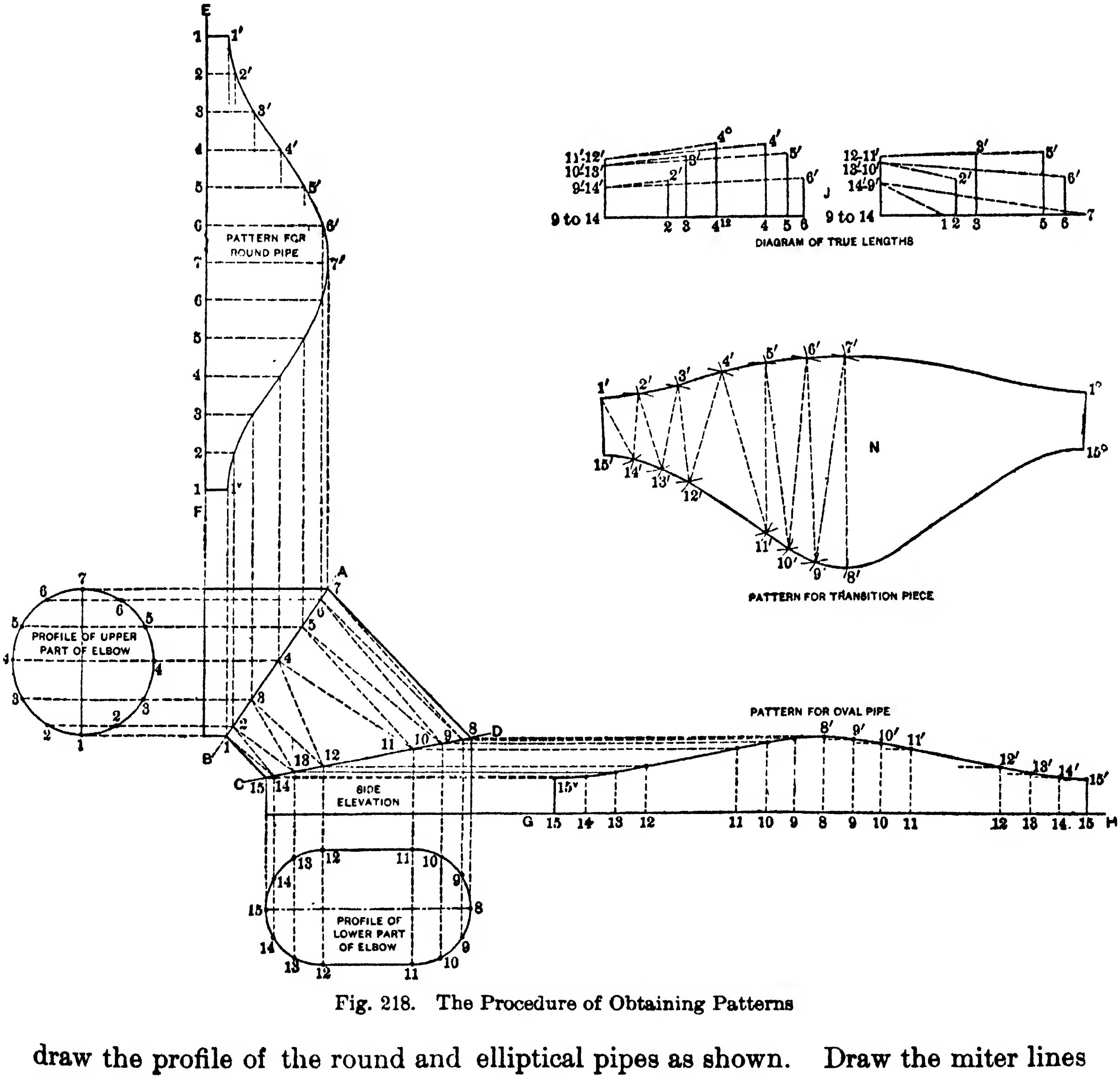


Fig. 218. The Procedure of Obtaining Patterns

draw the profile of the round and elliptical pipes as shown. Draw the miter lines A B and C D.

To obtain the pattern for the upper part of the elbow, divide the circular profile into equal spaces as shown from 1 to 7, from which points draw horizontal lines until they cut the miter line A B as shown by similar numbers. Perpendicular to

these lines draw the line E F, upon which place the girth of the circular profile as shown from 1 to 7 to 1. From these points horizontal lines are drawn and intersected by perpendicular lines erected from similar numbered intersections on the miter line A B. A line traced through points thus obtained, as shown from 1′ to 7′ to 1ᵛ will be the desired miter cut and 1 1′ 1ᵛ 1 will be the pattern for the upper arm of the elbow.

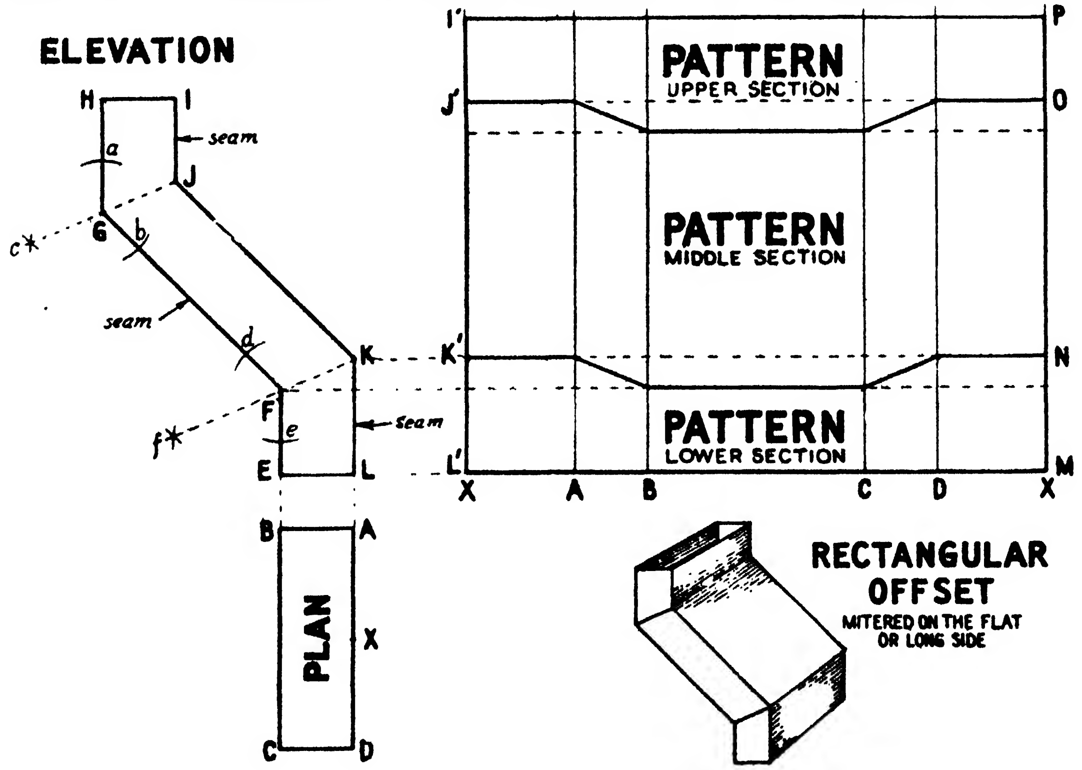
In a similar manner obtain the pattern for the lower arm. Divide the elliptical profile into equal spaces as shown from 8 to 15 and carry up vertical lines until they intersect the miter line C D as shown by similar numbers. In line with the lower arm draw the girth line G H, upon which place the girth of the elliptical profile as shown by similar numbers. At right angles to G H from the various points of intersections, erect vertical lines, which intersect by lines drawn parallel to G H from similar numbered intersections on the miter line C D. A line traced through points thus obtained as shown by 15 15′ 8′ 15ᵛ 15 will be the desired pattern. To obtain the pattern for the middle piece of the elbow, a set of true lengths must first be obtained as follows: Connect the various points on the miter lines A B and C D as shown. These lines represent the bases of sections which will be constructed, the altitudes of which are equal to the various hights in the semi-profiles of the two arms of the elbow.

For example: To obtain the true length of the line 11 4 in the side elevation, take this distance and place it as shown from 11 to 4, to the left in diagram J. From the points 11 and 4 in J, erect vertical lines making 11 11′ and 4 4′ equal respectively to the distance measured from the center line 1 7 to the point 4 in the round profile, and the distance measured from the center line 8 15 to the point 11 in the elliptical profile. A line drawn from 4′ to 11′ in J will be the true length of 4 11 in the side elevation. In this manner obtain the true lengths of all the dotted lines shown in the middle section in the side elevation, as indicated in the two diagrams in J. These true lengths having been found and as the miter cuts in both the pipe patterns give the true edge lines, the transition or middle piece is found as follows: Take the length of 7 8 in the side elevation and place it as shown by 7′ 8′ in N. With the distance from 8′ to 9′ in the miter pattern of the oval pipe as radius, and 8′ in N as center, describe the arc 9′, which intersect by an arc struck from 7′ as center and 7 9′ in diagram J as radius. Again, using 7′ 6′ in the miter pattern for round pipe as radius, and 7′ in N as center, draw the arc 6′, which intersect by an arc struck from 9′ as center and 9′ 6′ in diagram J as radius. Proceed in this manner, using alternately first the division in the miter pattern for oval pipe, then the proper true length in J; the division in the miter pattern for round pipe,

then the true length in J until the last line 1′ 15′ in N has been obtained, and which is equal to 1 15 in the side elevation.

It will be noticed that after the line 4′ 12′ in N has been obtained the pattern is continued from this line, by first using the division on the miter pattern for round pipe, etc. A line traced through points of intersections thus obtained will be the half pattern as shown by 1′ 7′ 8′ 15′. If the full pattern is desired, reverse on the line 7′ 8′ as shown by 7′ 1° 15° 8′.

Rectangular Offset Mitered on Flat or Long Side.—A manner of laying out the patterns which makes it possible to cut out the entire offset from one piece of metal. Since this offset is mitered on the long side of the rectangle, obviously the short side will appear in elevation. Draw the plan as shown and designate the corners as *A,B,C,D*, or by numbers if desired. Extend the line *CB*, and erect the line *EFGH*, in elevation, representing the angles of offset elbows required. Bisect the angle *EFG*, and obtain the miter line *FK*, as follows: With *F*, as center and any convenient radius, draw arcs, cutting the angles at *d* and *e*. Now, with a slightly greater radius and *d*, and *e*, as centers, draw arcs intersecting each other at *f*. A line drawn from *f*, through *F*, indefinitely, will be the required miter line. Bisect the angle *FGH*, in like manner, as indicated by *a*, *b*, and *c*, thus obtaining miter line *GJ*.



With the miter lines established, complete the elevation indicated by *EFGHIJKL*, as shown.

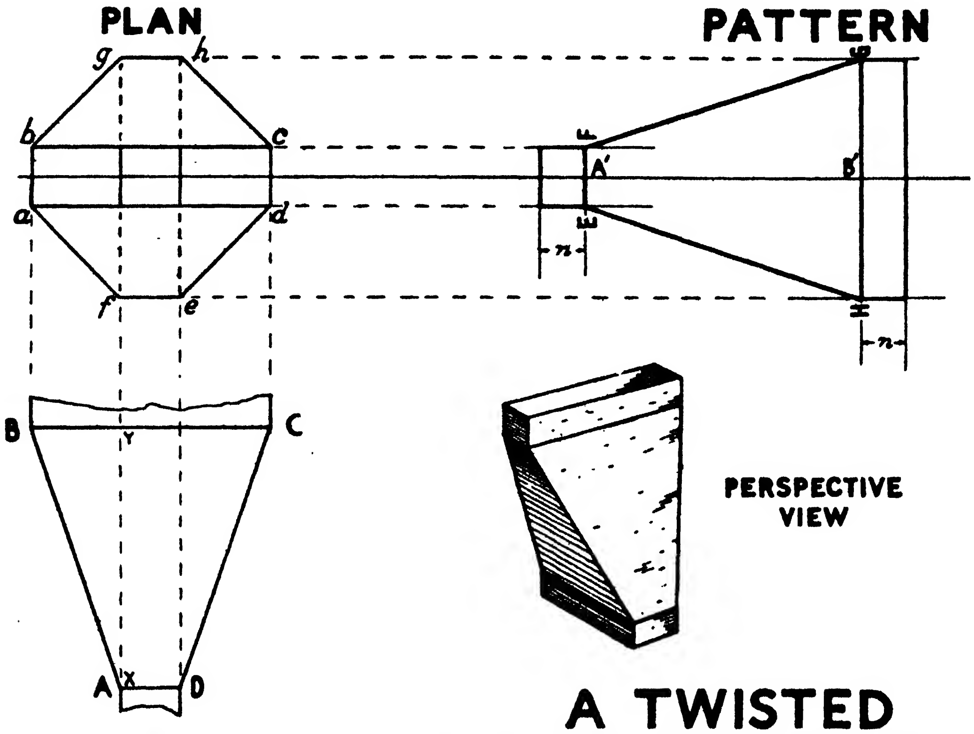
The two angles of this offset are alike since both upper and lower arms run parallel; hence the pattern for one angle will suffice for all.

For the patterns, lay off, consecutively, on the line *EL*, extended as *EM*, the four sides of the plan *ABCD*, beginning and ending at the seam *X*, as shown by *XABCDX*, from which points erect vertical lines indefinitely as shown and interersect them by lines drawn parallel to *L'M*, from intersections on miter line *FK*. Trace a line from *K'* to *N*, reproducing miter line *FK*, from *A* to *B* and from *C* to *D*, as shown. Then *K'L'MN*, will be the pattern for the lower arm or section. Take length of *FG*, or *JK*, and set it off on pattern lines from *K'* to *J'* and from *N*, to *O*. Draw line from *J'* to *O*, reproducing miter cut shown by *K'N*. Now take the length of *IJ*, in elevation and set it off on pattern lines from *J'* to *I'* and from *O* to *P*, and draw a line from *I'* to *P*; thus completing the pattern shapes for the three sections of the offset shown in elevation, with the seams occurring in center of long sides as indicated by the arrows.

A Twisted Rectangular Duct.—This is a fitting having two pipes identical in shape placed centrally one above the other. The letters *a,b,c,d* and *e,f,g,h* in plan, represent the profiles of the upper and lower pipes respectively.

It is obvious that since the projection of all four sides is the same, it is necessary to construct but one elevation as shown by *A,B,C,D*; making its required height as *XY*, and thus determining the true length of the sides *AB* and *DC*.

To lay out the one pattern which serves for all four sides: Through the center of the profile *a,b,c,d*, in plan, draw a horizontal line to the right indefinitely. Take the length of slant height *AB*, in elevation and set it off on this line as shown by *A'B'*. Through these points draw the measuring lines *EF* and *GH*, at right angles to *A'B'*, and intersect them by lines drawn parallel to *A'B'* from the profiles in plan, as shown; add the collars indicated by "*n*", and complete pattern *EFGH*. Allow sufficient lap for seaming on all four patterns.



ELEVATION

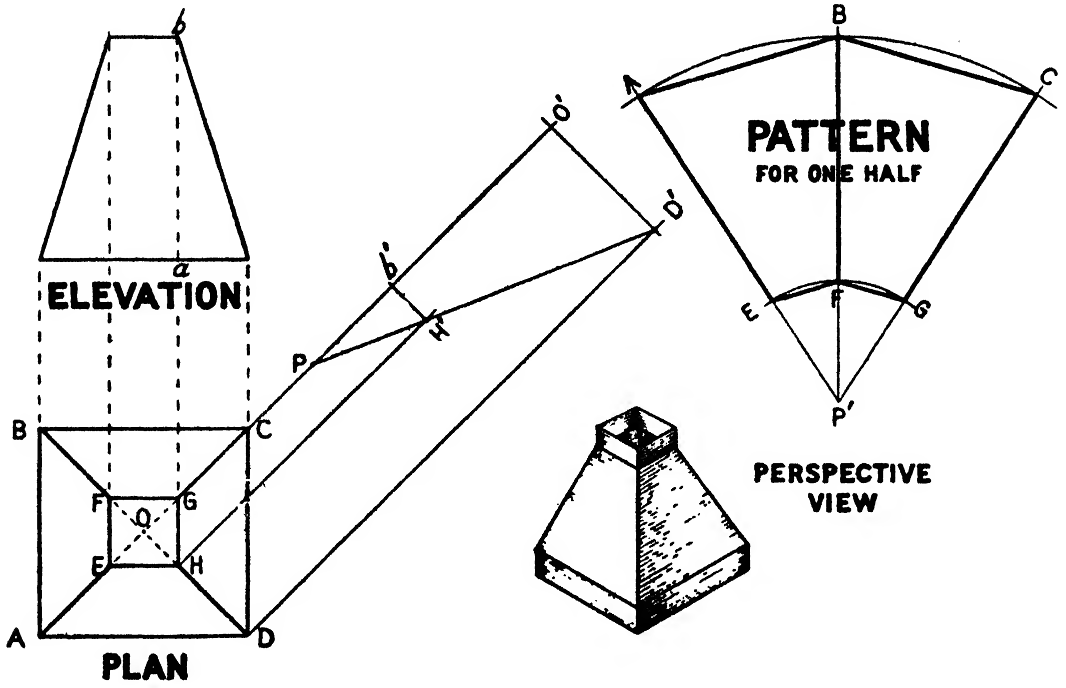
A TWISTED RECTANGULAR DUCT

A Square to Square Taper.—It is readily apparent from the perspective view that this fitting is a simple reducing joint, and that it has the shape of a four sided pyramid. The principles of the method used to develop the patterns for such figures, is fully explained.

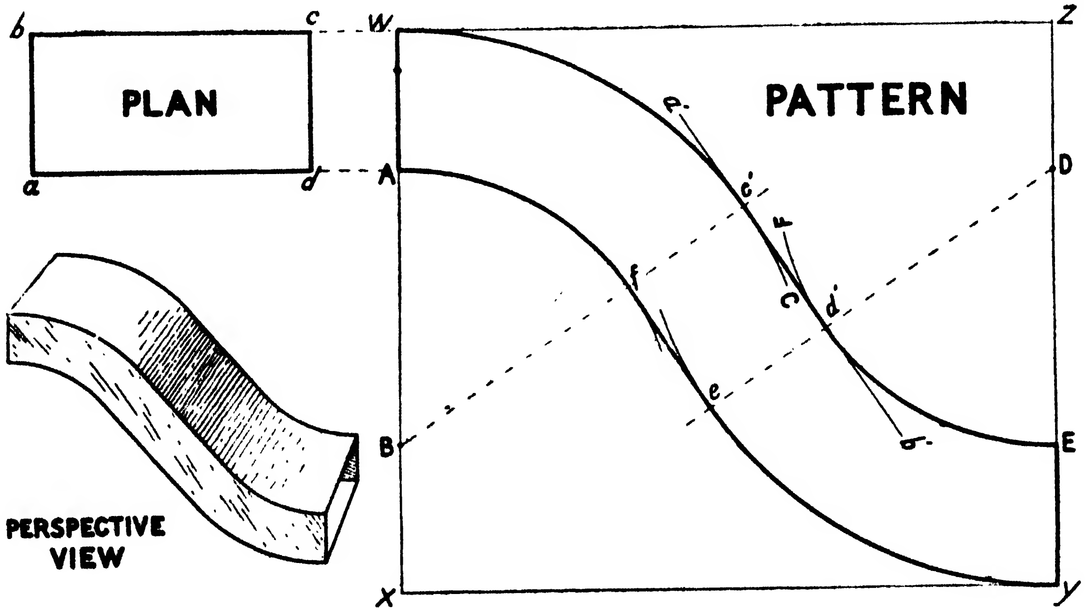
Lay out the plan by drawing the profile of the large pipe represented by *ABCD* in plan, draw in the diagonal lines intersecting at *O*, and put in the profile of the small pipe as shown by *EFGH*. The vertical height of the joint is indicated by the distance *a,b*, in the elevation.

To develop the pattern proceed as follows: From the points *O* and *D*, in plan and at right angles to the line *OD*, draw lines indefinitely and intersect them by the line *O'D'* drawn parallel to *OD* in plan.

Take the distance of the vertical height *a,b*, in elevation and place it on the line from *O'* to *b'*. From *b'* draw a line at right angles to *O-O'*, and intersect it by line drawn from *H*, parallel to *O-O'*, and establish the point *H'*. Now from *D'* draw a line through *H'* to the line *O-O'* at *P*. With *P'* as center and *PH'* and *PD'* as radii, strike the arcs *EG* and *AC*, respectively. Now with the dividers set at *AB*, and *BC*, in plan, point off these two distances on outer arc as indicated by similar letters. From the points *A,B*, and *C*, on outer arc draw lines to point *P'*, cutting the inner arc at *E,F*, and *G*. Trace a line through *ABCGFEA* and complete the pattern for one half the taper, *E,F,G*, in pattern equals *E,F,G*, in plan. Laps for seams are not shown in these patterns.



A SQUARE TO SQUARE TAPER



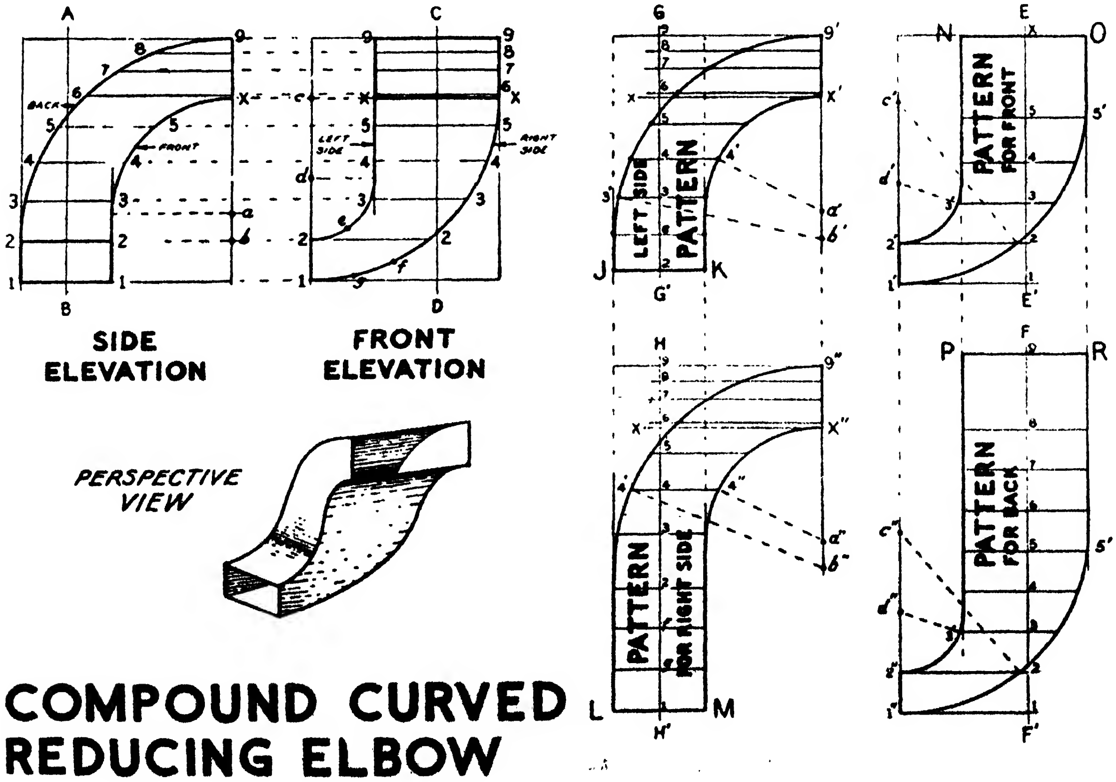
CURVED OFFSET HAVING RECTANGULAR PROFILE

Curved Offset Having Rectangular Profile.—Laying out an elbow to a given dimension. Begin by laying out the space according to dimension in which the offset is to be drawn, as represented by *WXYZ*; and place the plan *a,b,c,d* in position as indicated on page 189.

If, however, it be desired to draw the offset with the long side of the profile in elevation, place the plan so that its length *a,d,* will be in a vertical position parallel with *WX*, and proceed as follows: Take the width *c,d,* of plan and set it off on the line *WX*, as indicated by *WA*. Take the distance *a,d,* the widest part of the profile, and set it off from *A* as *AB*; with *B* as center and *BW*, as radius, strike the arc *WC*, indefinitely.

On the line *YZ*, measure off the distances *WA* and *AB*, as indicated by *YE* and *ED*. Using *D*, as center and *DE*, as radius, draw arc *EF*, indefinitely. Connect the arcs *WC*, and *EF*, by drawing a line tangent to them as shown by *a'b'*; and from the points of tangency draw radial lines *c'* to *B*, and from *D*, through *d'* indefinitely. Then with *B*, as center and *BA*, as radius describe an arc intersecting the radial line at *f*; in like manner with *D*, as center and *DY*, as radius, draw an arc passing through the radial line at *e*. Connect *e* and *f*, and the form *W,E,Y,A* is the pattern for the offset.

When the dimensions are such that the offset cannot be made in one piece, the elbows are made separately and connected by a straight piece of pipe joined at *c'f* and *d'e*.



COMPOUND CURVED REDUCING ELBOW

Compound Curved Reducing Elbow.—An elbow of this sort is not infrequently found where high class work prevails. This one makes a quarter turn in both front and side elevations. In the elevations as presented, the two profiles are plainly shown by their heavy outlines; the small profile *1-2-2-1* in the side elevation is shown in the front elevation by the line *1-2*; and the line *9-X* in side elevation, shows the profile *9-X-X-9* in front elevation.

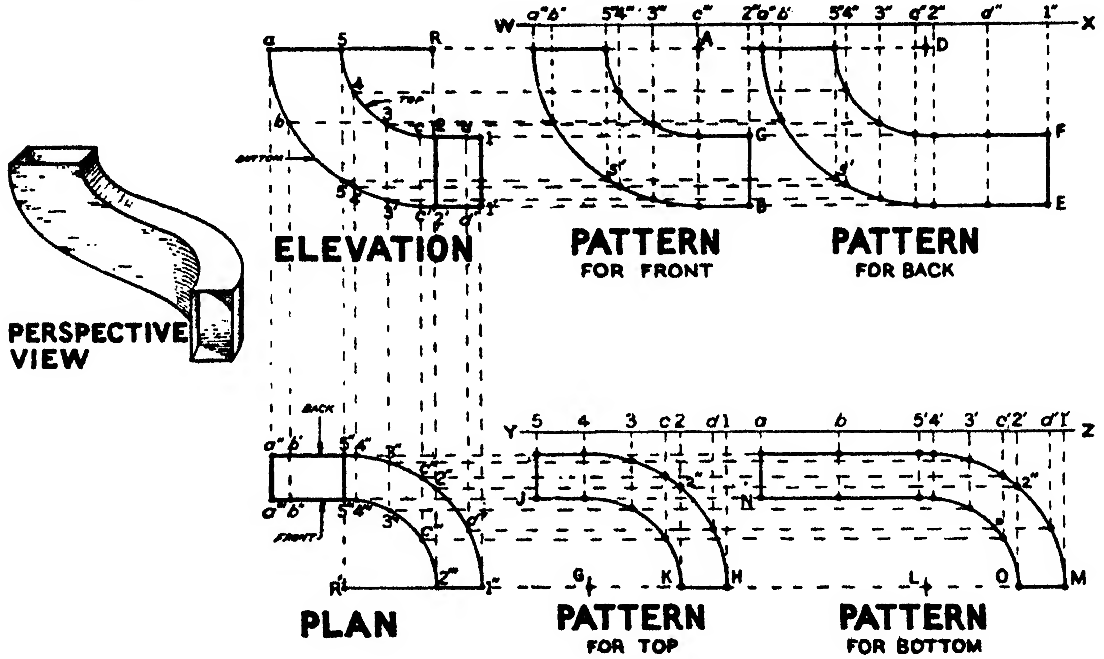
Draw the elevations as shown, according to given dimensions; the throat and heel curves in side elevation being drawn from centers *a* and *b*, respectively, and in the front elevation, from *d* and *c*, respectively. Bisect the profiles in both elevations by perpendicular lines as *A-B* and *C-D*. Point off an equal number of spaces on the back curve as indicated, and from these points draw horizontal lines to the right, cutting across both sides of front elevation as shown by corresponding numbers. Add the points *e*, on the left side, and *f*, *g*, on the right side to insure greater accuracy in taking the girth.

Beginning with the pattern for left side: With the dividers, take the girth of the left side in front elevation and lay it off on a vertical line, as *G-G′* and through these points draw horizontal lines indefinitely. Then from the line *AB* in side elevation, take the distances to the numbered points at the right and left of line, and put them to the right and left of the line *G-G′* on like numbered lines as shown. Drop a perpendicular line from 9′ through *X′* indefinitely. Take the distance from *9* in side elevation to points *a* and *b*, and place them on the line from *9′* as centers *a′* and *b′*. Using *a′* as center, draw arc *X′-4′* and with *b′* as center, draw arc *9′-3′*; complete the outline and *J-9′-X′-K* is the pattern for left side.

For the pattern for the right side, extend the vertical line *G-G′* as *H-H′*, and place on it the girth of the right side in the front elevation, and draw the usual measuring lines through the points, at right angles to *H-H′*. Take the numbered points to the right and left of the line *AB*, in side elevation, and put them to the right and left of the line *H-H′* as in the pattern for left side. The arc for the throat is drawn from *a″* as center, and the arc for the heel from *b″* as center. The completed outline shows *L-9″-X″-M* as the pattern for the right side.

The patterns for the front and back are arrived at in a similar manner. For the front, place the distances *1-X* in side elevation, on the vertical line *E-E′* as shown, and draw horizontal measuring lines through them. From the line *C-D* in front elevation, measure the distances from the points *1* to *X*, on the right side, and *2-X* on the left side, placing them to the right and left of the line *E-E′* as indicated. To locate the centers *c′* and *d′*, measure the distance from *1* to *d* and *c*, in front elevation, and place them on a line drawn from *1′* through *2′* as shown. From *c′* as center, describe the arc *1′-5′*, and using *d′* as center, draw the arc *2′-3′*, complete the outline and *1′-2′-N-O* shows the pattern for the front.

For the back pattern, set out the girth on vertical line *F-F'* as indicated by the numbers, and draw the usual measuring lines. Locate the intersection points by taking the distances of the projections each side of the line *C-D* in front elevation, and placing them to the right and left of the line *F-F'*. Fix center points *c''* and *d''* as in front pattern; describe the arcs *1''-5'* and *2''-3'* respectively, draw the straight parts and finish the outline; then *P-R-1''-2''* will be the pattern for the back. No allowance has been made for seaming.



COMPOUND CURVED OFFSET

Compound Curved Offset.—Here is an offset which curves in both the front and the side elevations, with the two profiles of the same dimensions, but in different positions. The upper one occupies a horizontal position and the lower one a vertical position.

To develop the patterns begin by drawing the elevation and plan in the proper relative position as follows: Draw the profile of the opening represented by the heavy lines *1-2-2'-1'* in elevation and with *R-2* as the given radius of throat, draw the quadrant *2-5*; using *R*, as center and *R-2'* as radius, draw the heel *2'-a*. Then *1-1'-a-5* shows the elevation.

Below the elevation and in direct line with it, construct the plan. Drop perpendicular lines from points *1,2,5* and *a*, in elevation, and on the line from point *5*, locate the point *R'*. With *R'* as center and *R'-2'''* as radius, describe the arc *2'''-5'''*, take the width of the narrow side of the rectangle and set it off on the perpendicular line *5-R'* from *5'''* to *5''*, and with *R'* as center and *R'-5''* as radius draw the arc *5''-1''* for the heel; complete the rectangle *5''-a''-a'''-5'''* as shown, thus completing the plan and elevation.

The curves in both views of this offset are the same, being quarter circles; sometimes they are elliptical or irregular in shape, but in any case the same principles of pattern development as here employed, would be applicable. As a means of quick identification, the four sides of this offset shown in elevation and plan are designated by their names in small letters.

Divide the curve of throat in elevation into any number of equal spaces, as shown by the figures *2,3,4* and *5*. (Use more divisions in actual work to facilitate measuring the girth), from which points drop perpendicular lines intersecting the heel in elevation, and the heel and throat in place at points indicated by similar figures. As the space in the heel in elevation between the points *a* and *5′* is too great, fix an extra point as at *b*, and from *b*, drop a perpendicular line intersecting the profile in plan at *b′* and *b″*.

As the space in the throat in plan between *2‴* and 3‴ is too great, therefore an extra point is established as at *c‴*, and from there a perpendicular line is erected to intersect the heel in plan at *c″* and the heel and throat in elevation at *c′* and *c* respectively. For the same reason an extra point is fixed in the heel in plan between *1″* and *2″* as at *d″* from which a perpendicular line is erected to intersect the rectangle in elevation at *d′* and *d*.

Having located the measuring points on all four curves in both views proceed to develop the patterns.

Parallel to *R-a* in elevation draw a line as *W-X*. Beginning with the pattern for the front *a‴-2‴* in plan, take this girth and set it off on the line *W-X* as shown by similar numbers and letters. From these numbers and letters drop perpendicular lines indefinitely, and intersect them by lines drawn parallel to *W-X* from similar numbers and letters in the top and bottom curves in elevation.

Since the space *5‴-a‴* in plan is in a horizontal plane, it is apparent that the pattern for that space for both front and back, will be a replica of the segment *5-5′-a* in elevation. Therefore this sequence must be reproduced in both patterns.

For the front pattern, take the radius of *R-a* in elevation and set it off in pattern for the front from *a‴* to *A*. With the same radius and *A*, as center describe the arc *a‴-5′*. Continue the line through points of intersection to *B*, and draw line from *5‴* through intersecting points to *C*, as shown; join points *B* and *C* and *5‴* and *a‴* thus completing pattern.

For the pattern for the back, take the girth of the back *1″-a″* in plan, and lay it out on the line *W-X* as shown by corresponding numbers and letters. From these points drop perpendicular lines cutting through horizontal lines drawn from corresponding letters and numbers in elevation.

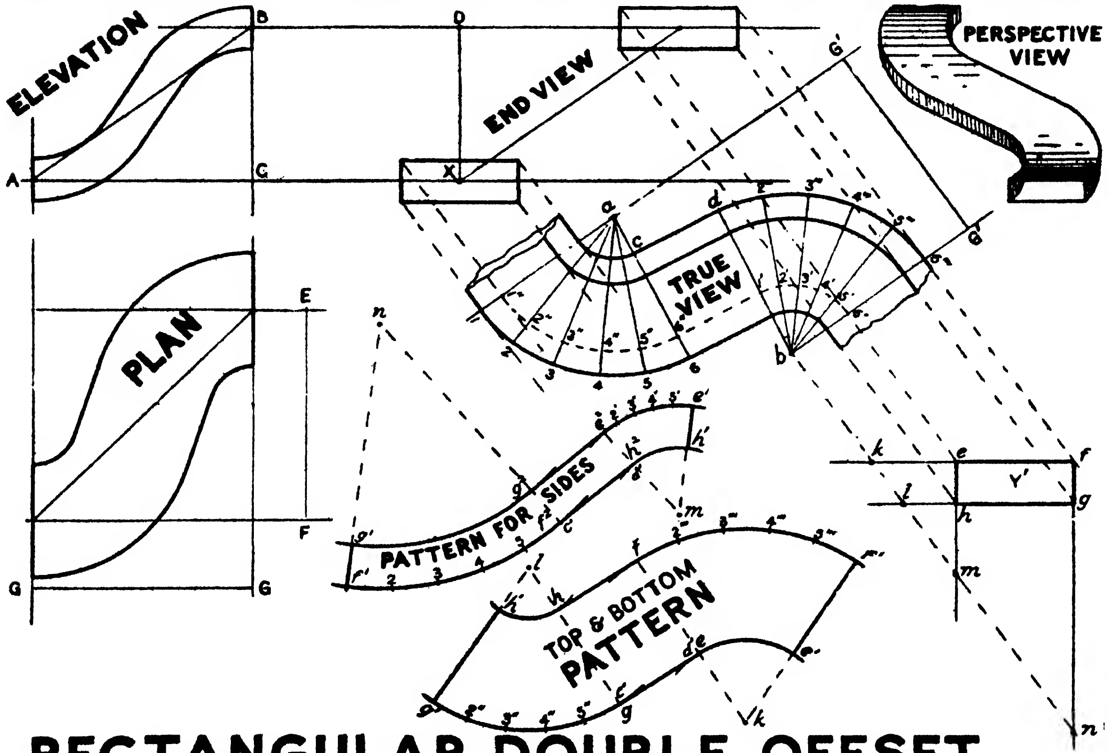
Take the radius *R-a* in elevation and set it off from *a″* to *D*, in pattern for the back and, with *D* as center, draw the curve *a″-5′*, thus again reproducing the segment *5-5′-a*; continue the line through points of intersection to *E*. Trace a line from *5″* through intersecting points to *F*, connect *E* and *F*, and *a″-5″* thus defining the pattern.

Draw the stretch outline *Y-Z* parallel to *R′-1″* in plan, and proceed as before.

For the pattern for the top *1-5* in elevation, take this girth and lay it out on the line *Y-Z* as indicated by its numbers and letters. Draw horizontal and perpendicular lines obtaining the points of intersection as shown. The space *1-2* in elevation being in a horizontal plane, its pattern shape would be a replica of the segment *1″-2-″-2‴* in plan. Reproduce this segment in pattern thus; take the radius *R′-1″* in plan and with *H*, as center, establish the intersecting point *G*. With *G*, as center and *G-H* as radius, draw the arc *H-2″*. Continue the line from *2″* through points of intersection to *5* and *J-K-H* thus completing the pattern.

For the bottom pattern, take its girth *1'-a* in elevation and stretch it out on the line *Y-Z* as shown, and obtain the intersecting points of perpendicular and horizontal lines as previously explained. Reproduce the segment *1''-2''-2'''* in plan by taking the radius *R'-1''* in plan and with *M* in pattern as center locate the point *L*. With *L* as center and *L-M* as radius, describe the arc *M-2''*. Through the established points of intersection, continue the line from *2''* to *a*, and to *N-O-M* which completes the pattern.

In these patterns no allowance has been made for seaming; hence proper laps should be added. Be careful to roll the patterns so that the elbow will turn in the right direction.



RECTANGULAR DOUBLE OFFSET

Rectangular Double Offset.—The requirement of this offset is that it shall retain the same sectional area throughout. Therefore the development of the patterns is such as to achieve that result.

In addition to the plan and elevation there is shown an end view, from which it should be observed that center lines is the basis of the pattern development.

Draw in the plan and elevation as shown, the vertical height of elevation between centers being as indicated by *C-B*. Extend the center lines *AC* and *BY* in elevation to the right indefinitely, and draw in profile of pipe as shown at *X*. From *X* draw vertical to interset *B-Y*, and locate point *D*; Set off to the right from *D*, the distance *E-F*, in plan and establish point *Y*; draw profile with *Y* as center; and connect profiles by center line *XY*; thus completing the end view.

As a means of simplifying the method of developing the patterns, and for ascer-

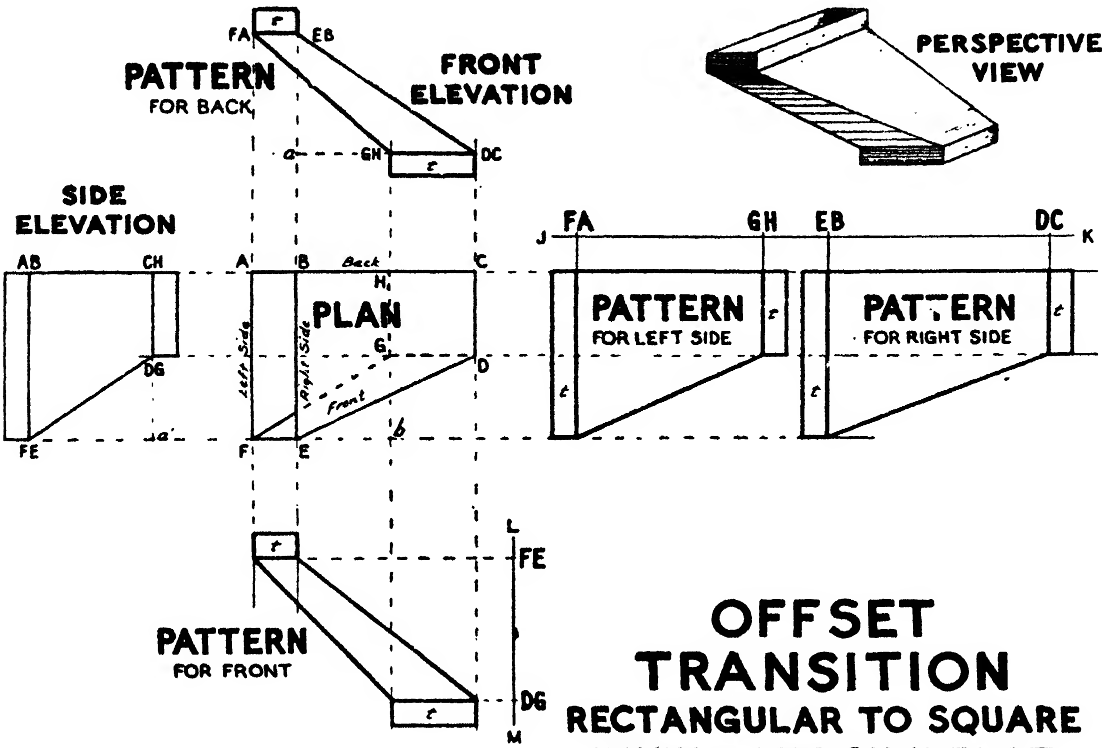
taining the curves for heel and throat, a true view is erected in line with the end view as shown, according to the following procedure: From the angles of the profiles *X* and *Y*, draw lines at right angles to the center line *X-Y*, indefinitely; draw the lines *aG′* and *bG′* horizontal to the perpendicular from the profiles, and separated by a distance equal to *GG* in plan as indicated by *G′G′*, locate the points *a* and *b*, as centers for throat and heel curves. Complete the true view as shown.

Extend the lines from profile *Y*, sufficiently far below the true view and duplicate the profile as shown by *Y′*. Extend the top and bottom lines of *Y′* to the left and the side lines downward to intersect the line *bn*, drawn at right angles to *XY*, from *b*. From the point thus obtained, we get the length of radaii, for the patterns.

Beginning with the pattern for the sides: With *n*, as center, and *n,f*, and *n,g*, as radaii, draw arcs f'-f^2 and g'-g^2 in pattern, making g'-g^2 equal to the curve *1* to *6* in true view, as shown by similar figures. Add the straight parts *c′-d′*, which should equal *c-d* in true view; then with *m*, as center and *m,e*, and *m,h*, as radaii, strike the arcs as indicated by similar figures, making e^2-e' equal to *1′* to *6′* of true view as shown, thus completing pattern.

The pattern for the top and bottom is drawn in the same manner. From *l* in pattern as center, with *l-g* and *l-h* as radaii describe the arcs, making *g′-g* equal to *1″* to *6″* of true view as shown, add straight part *c′-d′* equal to *c-d* of true view. Complete the pattern by striking arcs *e-e′* and *f-f′*, from *k*, as center, making *f-f′* the same length as *d-6‴* in true view, as is shown by corresponding figures.

It should be remembered when putting this fitting together that though the patterns for both sides are alike, they should be reversed to each other. This also applies to patterns for top and bottom.



OFFSET TRANSITION
RECTANGULAR TO SQUARE HAVING ONE SIDE FLAT

Offset Transition—Rectangular or Square Having One Side Flat.—This fitting is not an uncommon one. While the two profiles are different in contour, they are equal in area.

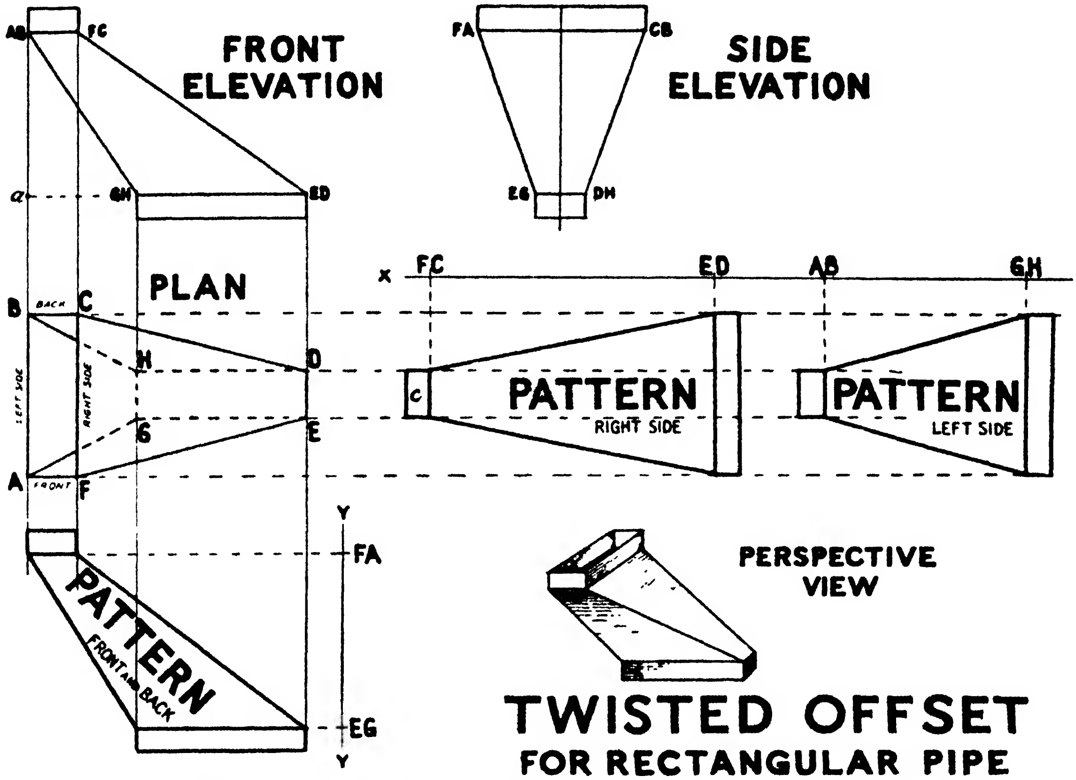
As the upper and lower profiles of this offset run flush in the back, therefore the back when shown in elevation appears as the front elevation and also becomes the pattern for the back.

Draw in the plan as shown with *ABEF* representing the profile of the rectangular pipe at the top, and *HCDG* the profile of the square pipe at the bottom which offsets a distance equal to *Eb*, in plan. Construct the front elevation with its required vertical height equal to *a-EB* in elevation, as shown, and *FA*, *EB*, *DC*, *GH*, will be the pattern for the back.

Erect the side elevation as shown, having its vertical height *a'-FE* equal to *a-EB*, in front elevation. Take the distance *FE-DG* in side elevation and stretch it out on a vertical line as *LM* below the plan; from these points draw the horizontal lines to intersect the perpendicular lines drawn from corresponding letters in plan. Draw a line through the points of intersection and these form the pattern for the front *FEDG* in plan.

Extend the horizontal lines *AC*, *GD*, and *FE* in plan to the right indefinitely; and above them draw another horizontal line as *JK*, on which set off the distances *FA-GH* and *EB-DC* in the front elevation as shown.

Draw the usual measuring lines vertically from these points to intersect the horizontal lines from similar letters in plan, connect the points thus obtained and complete the patterns for the two sides as shown. Add the collar "*t*" to top and bottom of all four patterns, also laps for seams.



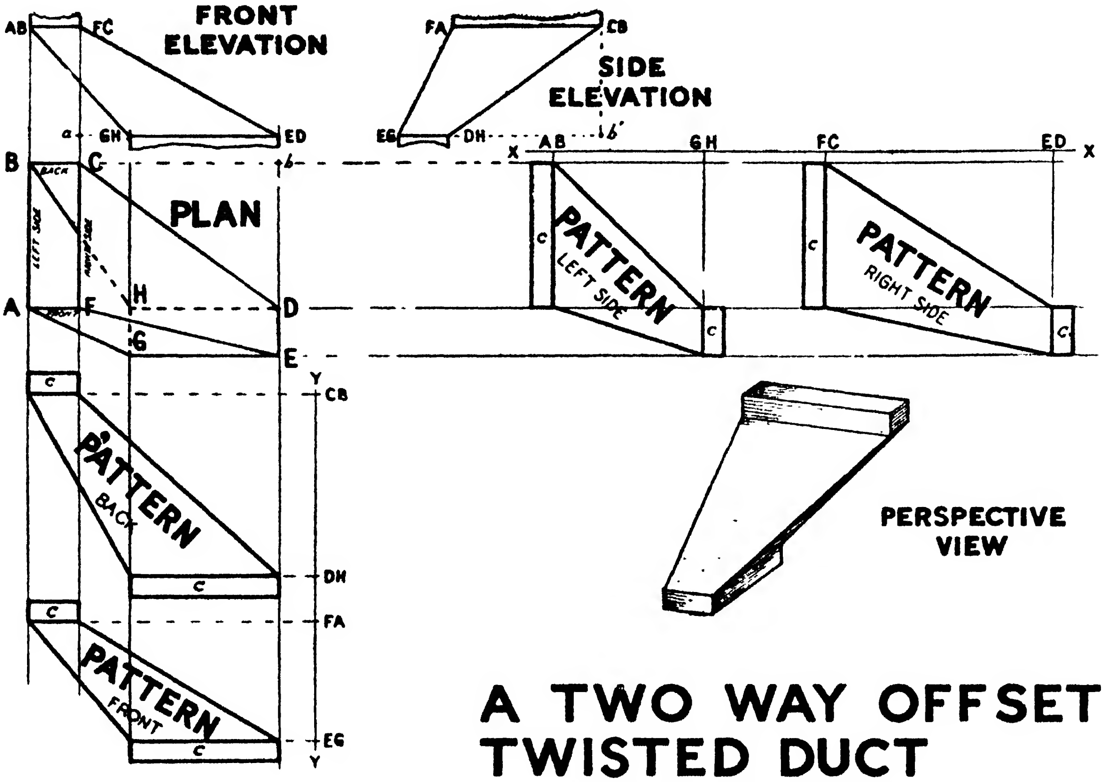
TWISTED OFFSET
FOR RECTANGULAR PIPE

Twisted Offset For Rectangular Pipe.—This fitting is a variation of Fig. page 188 having both profiles alike and centrally placed in relation to each other, but offset a distance equal to *a-GH* in front elevation.

Lay out the plan as shown, with *ABCF* representing the upper profile and *GHDE* the lower profile. Erect the front elevation from the plan as indicated, its required vertical height being the distance from *a* to *AB*, as shown in elevation. In line with the front elevation erect the side elevation giving it the same vertical height.

Then *FC-ED* and *AB-GH* in the front elevation show the actual lengths of material required for the right and left sides shown in plan. Set these lengths off on the horizontal line *XX* as shown; and from these points drop perpendicular lines indefinitely, and intersect them by horizontal lines drawn from similarly lettered points in plan. Draw the outlines connecting the intersecting points and the result will be the patterns for the right and left sides.

Drop vertical lines from the points *A,F,G* and *E*, in plan, and the vertical line *YY*, at the right; on which place the distance *FA-EG* in side elevation, and draw lines from these points at right angles to *YY* cutting the vertical lines from the plan. Draw the outline connecting the points and complete the pattern; as both sides in the side elevation are alike, this will be the pattern for the front and back. Add to top and bottom of the patterns the collars "*c*" and sufficient laps for seams.



A TWO WAY OFFSET TWISTED DUCT

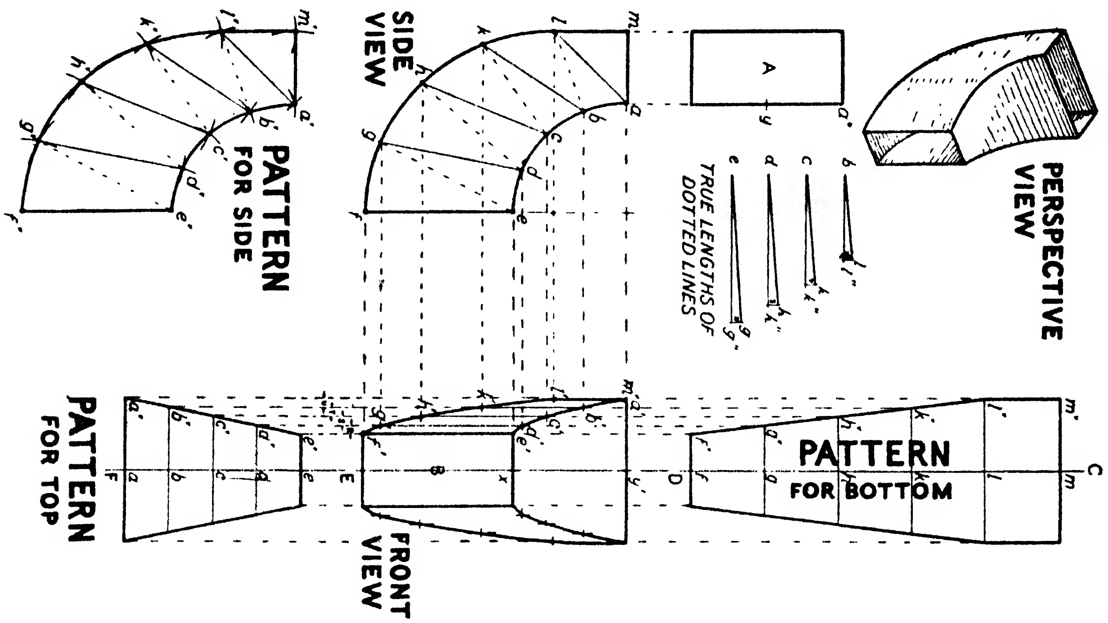
A Two-Way Offset Twisted Duct.—This fitting like the previous one, has two profiles identical in shape, making a quarter turn, but differs in that it is offset both ways.

The patterns for this fitting may be developed as follows: Assuming that *ABCF* in plan is the required profile of the upper pipe, and *GHDE* the profile of the lower pipe, and that *b* to *D*, and *b* to *C*, is the amount of offset both ways, draw in the plan as shown.

Erect vertical lines from profiles in plan as shown, and construct the front elevation according to the given height as represented by *a* to *FC*, in elevation, and in line with the front elevation, construct the side elevation as shown with the offset *b'* to *DH* equal to *b* to *D*, in plan.

Draw any horizontal line as *XX*, and set off on it the lengths *AB-GH* and *FC-ED* which are the actual lengths of the right and left sides. From these points drop perpendicular lines and intersect them by horizontal lines drawn from similarly lettered points in plan as shown; connect the points by the diagonal lines and complete the patterns for the right and left sides.

Now draw any perpendicular line as *YY*, and set off on it the actual lengths *CB-DH* and *FA-EG*. From these points draw horizontal lines to the left intersecting the perpendicular lines drawn from similarly lettered points in plan; connect the points by the diagonal lines and complete the patterns for the back and front of the offset as shown. Add the collars indicated by "*c*", at top and bottom to all patterns. Allow laps for seaming as required.



TRANSITION ELBOW

RECTANGLE TO RECTANGLE

Transitional Elbow—Rectangle to Rectangle.—In the planning of heating and ventilating work, a transitional elbow of this type is frequently used. It is a transition of the same profile from a horizontal to a vertical position, making a quarter turn.

Sometimes a twist in the checks or sides of the elbow is developed by the way in which the patterns are laid out; therefore to obviate that, the present method is employed.

Construct the side view with the given radaii for throat and heel, as shown by *a-e-f-m*. Above it draw the profile of the pipe as indicated by rectangle *A*; to the right and in line with *e-f* draw the other profile as represented by rectangle *B*.

Locate the center of the narrow side of rectangle *B*, as at *x*, and through it draw the perpendicular line *C-F*. Likewise bisect the wide side of rectangle *A*, as at *y*. Extend line *m-a* in side view to right indefinitely, and to the left from center line *C-F*, set off on it the distance *y'-a'* equal to *y-a°* in profile *A*.

Divide the throat and heel curves of side view each into the same number of spaces, as shown by *a-e*, and *f-l*. Transfer the girth of the upper or throat curve, *a* to *e*, to the line *EF*, as shown by similar letters. Through these points draw horizontal lines as indicated, making the distance from *e* to *e°* equal to *x-e'* in profile *B*, and from *a* to *a°* equal to *y-a°* in profile *A*; draw a line connecting points *a°* and *e°* which will show the half pattern; reproduce this to the right of center line and complete the whole pattern for the top.

From the points of intersection a^v, b^v, c^v, d^v, e^v, on the line a^v-e^v, in pattern for the top, draw perpendicular lines indefinitely as shown. Now from the letters *a* to *e*, and *f* to *l*, in side view, draw horizontal lines to the right to intersect the verticals from top pattern and locate the points $a', b', c', d', e' f', g', h', k', l', m'$, in front view; draw lines through the point of intersection and obtain the miter lines in the front view as shown.

Take the girth of the heel, *f* to *m*, in side view, and place it on the vertical line *C-D* as shown by similar letters; at right angles to *C-D*, draw lines through these points cutting through the verticals from the top pattern and resulting in the points f^v, g^v, h^v, k^v, l^v and m^v draw a line through these points from f^v to m^v and trace the half pattern thus produced to the right of center line, and complete the pattern for the bottom.

The pattern for the sides is developed by triangulation; hence it is necessary to determine the true lengths of the lines in the triangles that are to be used for making up the required patterns. To do this, take the vertical rise of each line, in one of the views as one leg, and the apparent length of each line, as it appears in the other view for the other leg; the hypotenuse gives the true length of the line.

Draw the solid and the dotted lines which form the angles in the side view, as shown. Since the solid lines in the side view show as vertical lines in the front elevation, as shown by similar letters, it may be assumed that the solid lines in the side view show their true length.

To find the true lengths of the dotted lines in side view; Take the line *e-g*, and set it down as one leg of a right angle triangle as shown by e-g''; for the other leg erect the vertical line g''-g to equal the horizontal distance between the lines e'-f' and d'-g in front view and indicated by *R*. A line drawn from *e* to *g* in the true lengths, will be the length sought. Proceed in this manner to find the remaining true length on dotted lines, using the horizontal distances marked *S*, *T*, and *U* in front view, for the shorter legs of the right angled triangles.

Having established the true lengths of the lines of measurement, proceed to lay out the pattern for the sides. Take the distance *e-f* in side view, this being its true length, and set it off as shown by e^v-f^v in side pattern. With f^v-g^v in bottom pattern as radius, and f^v in side pattern as center, draw the arc g^v and intersect it by arc drawn from e^v as center, and *e-g* in true lengths of dotted lines, as radius. Now, with e^v in side pattern as center, and e^v-d^v in top pattern as radius, describe an arc as at d^v and intersect it by an arc drawn from g^v as center, and *g-d* in side view (this being its true length) as radius.

Follow in this alternate manner, using a radaii, first the divisions on the miter line in the bottom pattern, then the true lengths of the dotted lines; next the distances on the miter line in top pattern, then the lengths of the solid lines in side view (which are their true lengths) until all the points a^v-e^v-f^v-l^v, in the side pattern are established, the triangle a^v-l^v-m^v being a duplicate of *a-l-m* in the side view. Draw a line through the points and complete the pattern. Allow laps for seaming.

SECTION II

(Pages 201-342)

SPECIAL SHEET METAL LAYOUTS

Practical Sheet Metal Work and Demonstrated Patterns

PATTERN FOR TAPERING PIPE INTERSECTING TWO CYLINDERS

This deals with a method of obtaining the pattern for a tapering pipe joining two cylindrical pipes, placed in position shown in Fig. 1. In this, B is the plan of the vertical pipe, shown in elevation by B^1, and C the plan of the tapering pipe, shown in elevation by C^1. D in the plan shows the inclined pipe, shown in elevation by D^1. E is the true pitch of the pipe on F H in plan. The pattern cut at the intersection L in elevation is not developed.

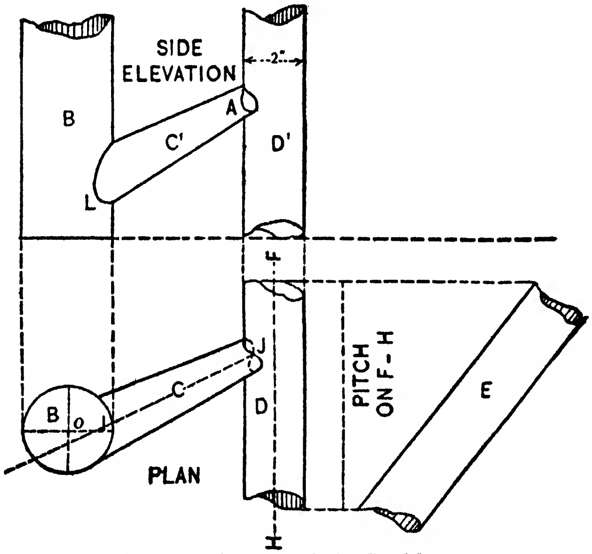


Fig. 1. Sketch of the Problem

The pattern for the cut A in elevation will be obtained as shown in Fig. 2, in which A B C shows the part plan view of the vertical pipe shown in elevation by E F G H. Referring to the plan in Fig. 1, it will be seen that the axis I J of the tapering pipe does not pass through the center of the circle O. Therefore, when drawing the plan in Fig. 2 assume that O in plan in Fig. 1 is the pivot, and turn C and D so that the axis I J of the tapering pipe will be a horizontal line, as has been done in Fig. 2, in which 4 R, the axis of the tapering pipe, lies horizontally. Through the center D draw D B. At the required distance below D B draw the axis of the cone or tapering pipe indefinitely, as 4 R.

Now draw the plan of the inclined pipe in its proper position and angle, making the length from 5′ to 5″ at pleasure, as shown by 5′ 5″ 1″ 1′. Draw the profile

J, which divide into equal spaces, as shown from 1 to 8. From these parallel to 5′ 5″ draw lines intersecting the ends of the pipe in plan, as shown by similar figures, 1′ to 8′ and 1″ to 8″.

Parallel to 1′ 1″ draw K L, which represents the line of the floor, at right angles to which and from L draw L M of the required hight desired, so that a line drawn from M to K will be the desired angle. Now take a tracing of the profile J and place it as shown by J^1, giving the circle a one-quarter turn so that the line 3 7 in the profile J will be at right angles to K M, as shown. Through the point 7 parallel to K M draw 7 7, which intersect with lines drawn at right angles to K L from 1′ and 1″ in plan, thus obtaining the lines 3 7 and 3 7 in the true angle, as shown. Through the small figures in the profile J^1 draw lines parallel to K M intersecting the vertical ends K 7 and M 7 at 1 to 7 at top and bottom. Then will K 7 7 M be the true angle on 7′ 7″ in plan.

The axis of the cone 4 R intersects the circle in plan at 2. From 2 at right angles to 4 R draw a line into the elevation, as shown by 2 2^x, the point 2^x in elevation being established at pleasure. From 2^x, at its proper angle to G F of the vertical pipe, draw the line 2^x S. Then with the apex S as center and S 2^x as radius describe the arc 2^x 4^x. Set the dividers equal to the distance that the tapering pipe is to have at its base, and using 2^x as center intersect the arc 4^x, as shown. From 4^x draw a line to S and another from 2^x to 4^x. Place the profile T in its proper position. From the center U draw a line to S, intersecting the circle at 1. Extending the line downward until it intersects the circle at 3, draw 2 4, thus dividing the circle into four equal spaces. At right angles to 2 4 in T, and from points 1 to 4, draw lines intersecting the base line 2^x 4^x at 2^x, 1^x, 3^x, 4^x. From the intersections 3^x, 1^x and 4^x drop lines into the plan, as shown by 4^x 4, 1^x 1 and 3^x 3. Now take the distances from U to 3 and U to 1 in the profile T and place them as shown in plan from U^1 to 3 and U^1 to 1 on the line drawn from 1^x and 3^x in elevation. Trace an ellipse through points 1, 2, 3 and 4 in plan, and draw lines from 1 and 3 to the apex R, which completes the plan and elevation for the tapering pipe.

The next step is to obtain an elevation of the inclined pipe. From the intersections 1′ to 8′ carry lines upward to the elevation (partly shown). Now, measuring from K in the true angle, obtain the various hights to 1 to 8, and place them on lines having similar numbers in elevation, measuring from E N, thus

obtaining the points of intersection 1 to 8. Trace through these points the ellipse O. In precisely the same manner obtain the ellipse P. Now connect similarly numbered points in the sections O and P, as shown.

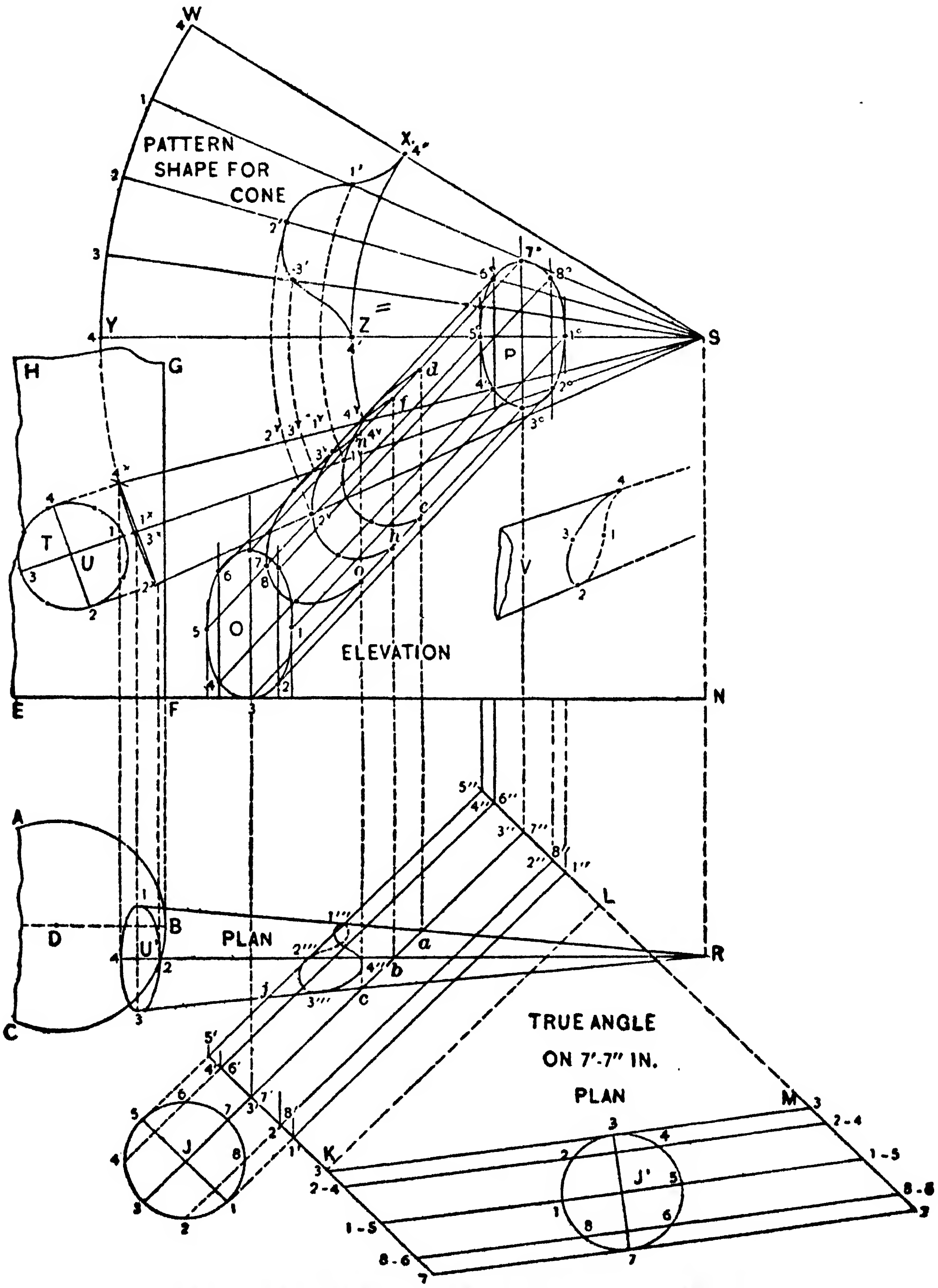


Fig. 2. Plan, Elevation, True Angle, Sections and Pattern

It will next be necessary to obtain sections in the elevation of the inclined pipe on the lines 1 R, 4 2 R and 3 R of the tapering pipe in plan, where they

cross the inclined pipe 5′ 5″ 1″ 1′. At right angles to 4 R and from the intersections where the line 1 R intersects the lines 5′ 5″, 4′ 4″, 6′ 6″, and 3′ 7′, 3″ 7″, of the inclined pipe, carry lines upward (partly shown) intersecting lines of similar numbers in elevation. Trace a line through the points, then will *d e* be the section on R 1 in plan. Where S 1, the vertical projection of the line, the horizontal projection of which is R 1, intersects *d e*, establish 1^v 1^v. In similar manner locate 4^v, 2^v and 3^v.

If a line was traced through the intersections 1^v, 2^v, 3^v and 4^v it would look as shown in diagram V. If for any reason it was desired to obtain the miter line in plan between the tapering and inclined pipe, then at right angles to E N in elevation and from intersections 1^v, 2^v, 3^v and 4^v drop lines intersecting cone lines having similar numbers in plan, as shown by 1‴, 2‴, 3‴ and 4‴.

For the pattern for the tapering pipe proceed as follows: At right angles to the axis of the cone U S in elevation, and from intersections 4^v, 1^v, 3^v and 2^v, draw lines intersecting the side of the cone 4^x S at 4^y, 1^y, 3^y and 2^y. With S as center and with radius equal to S 4^x describe the arc 4^x W. Draw any radial line, as Y S, and setting the dividers equal to one of the spaces in the profile T step off spaces on the arc Y W, as shown. From these draw radial lines to S. Now, using S as center and with radii equal to S 4^y, S 1^y, S 3^y and S 2^y, describe arcs, thus obtaining the intersections 4′, 3′, 2′, 1′ and 4′. Trace a line through the points thus obtained, then will X 2′ Z be the miter cut on the tapering pipe.

The opening in the pattern for the round inclined pipe would be obtained by projecting the miter line to the oblique elevation and developing as for an ordinary T.

PATTERNS FOR A HELICAL TAPERING PIPE

One of the inquiries received was to be shown how to develop the patterns for a tapering helical pipe, and, as an illustration of the idea, a small picture was sent of a blast furnace which is reproduced in Fig. 3, in which the arrow indicates what is known as the "down comer." In this picture the pipe is seen to descend first vertically to an elbow, whence it falls spirally around the body of the furnace. Careful inspection of the pipe seems to indicate that one or two sections or joints of the pipe only are made tapering. For the purpose of more fully demonstrating the principle involved, however, the spiral pipe has been given in the diagrams a continuous and uniform taper throughout its entire course, from which it can easily be seen how to vary the method to suit a pipe with an irregular taper.

The construction of an elevation of the spiral from which the exact angle of the elbows can be obtained will be the first thing sought. The conditions for accomplishing this in its entirety will, however, be found very unusual when it is discovered that such a view cannot be completed until a correct view of each and every joint of the pipe has been constructed in which is to be found every detail necessary to the development of its pattern. The work is best begun by the construction of a plan and elevation of the axis of the pipe—that is, the axial lines of the several joints, it being understood that the diameter of the furnace body, the diameter of the helical pipe at its upper and its lower end, the hight of the fall, its circumferential length on the plan and the number of pieces required are all given.

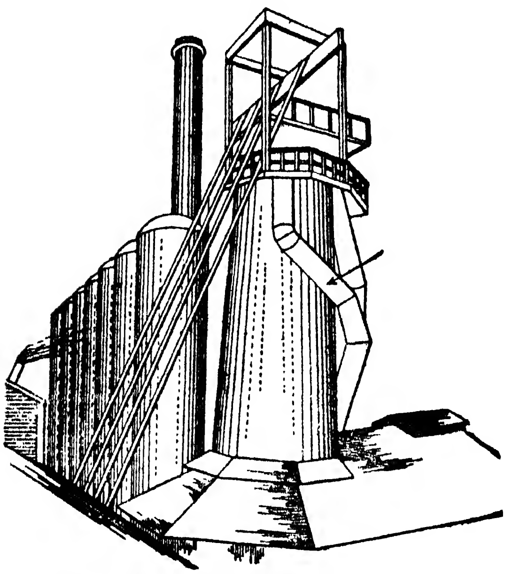


Fig. 3. Tapering Down Comer of a Blast Furnace

Therefore draw first the plan of the furnace body as shown by *a b c* of the plan in Fig. 4, the center of which is at *d*. Upon the supposition that the helical pipe is to extend through half a circle in the plan, extend the center line of the plan in either direction, and set off on the same at one side (the left) the diameter of the smaller end of the pipe as shown by *c f*, and at the other side the diameter of the larger end as shown by *g h*, making such allowances from *a* to *e* and from *c* to *g* as will allow the several pieces of the pipe to clear the furnace body at their middle portions, the said pieces appearing in the plan as tangents to a circle. Here occurs the first instance in which extreme accuracy cannot be insured, since these allowances can be only approximated or obtained by experiment. Bisect *e f* and *g h*, obtaining the points 1 and 6. Then bisect the distance 1 6, obtaining the point *i*, from which a semicircle may be drawn from 1 to 6 as shown. It being granted that the angle of the fall of the pipe is to be uniform in every piece, and that it is to be made in five joints or pieces, divide the circle just drawn in the plan into five equal spaces as shown by the figures 2, 3, 4 and 5, and through each of these points draw a line of indefinite length toward the center *i*, as shown outside the circle *a b c*.

The diameter of the pipe at its upper and lower ends having been indicated by *e f* and *g h*, uniformity in its taper may be obtained by the construction of a diagram of diameters as shown above the right of the plan, in which the diameter of the

inner circle is equal to *e f* and and that of the outer circle is equal to *g h*. If the space between these two circles be divided into five equal parts and circles drawn through the points of division, the intermediate circles may be assumed as the respective sizes of the pipe at the points 2, 3, 4 and 5 of the plan, and their diameters may be set off respectively on the radial lines previously drawn through the points just mentioned (half on each side as shown), and the points so found connected, thus forming the broken lines from *e* to *g* and *f* to *h*. It must be understood that this drawing does not constitute an accurate plan of the pipe for several reasons, its purpose being primarily to bring the sides of the pipe into the desired juxtaposition with the sides of the furnace body. When this matter has been satisfactorily adjusted, lines connecting the points 1 and 2, 2 and 3, etc., will then form an accurate plan of the axes of the several pieces, from which an elevation must be projected as shown above.

In the construction of the elevation of the helix the uniformity of its fall is maintained by drawing any vertical line, as G H, making it equal to the desired hight of the fall and dividing it into the same number of equal spaces as were used in dividing the plan, in this case 5, as shown by the figures 1′ to 6′. Lines drawn horizontally from the points 1′, 2′, 3′, etc., to intersect vertical lines erected from points of corresponding number in the plan, as shown by 1″, 2″, 3″, etc., will locate the central points of the several miters in the elevation, and the lines 1″ 2″, 2″ 3″, 3″ 4″, etc., will be the axial lines of the several pieces.

If from any cause it becomes necessary that the position of the points 2, 3, 4, etc., of the plan and 2′, 3′, 4′, etc., of the elevation should be arbitrarily fixed, the result would no doubt be such that every section of the helical axis would then stand at a different angle to the horizon. Such a condition would not vary the method of solution as given below, but would require an extra degree of care in determining the angles and locating the throats of the several miters.

In the subsequent operations of obtaining correct views of the several pieces from which the patterns can be developed, it is necessary that the axis of each piece shall first be brought into or parallel to the plane of the view in the elevation. This is accomplished by turning the plan into such a position on the drawing board that the axis of the piece under consideration shall be squarely in front—that is, shall lie horizontally across the board before the projection of the points into the elevation is made. In the plan as drawn the piece D, the axis of which is the line 3 4, conforms to this requirement. The result of this is that the line 3″ 4″ of the elevation is in the plane of the view and therefore represents the true length of the axis of piece D.

As the possibility of making the sides of the helical pipe parallel instead of tapering, was referred to, it may be stated here that in either case the operations as described up to this point, and, in fact, to the point wherein a correct and complete projection of a given piece is found, are the same. Beyond this it becomes, in the case of the pipe of uniform diameter, simply a question of miter cutting, but if the pipe be tapering, the pattern can best be obtained by means of triangulation. In either case the two great points of the problem are the finding of the correct angle between any two adjacent pieces and the relative distance, on the circumference of the pipe, between the throat points of the miters at the two ends of any piece, for upon this latter feature depends the pitch or fall of the spiral. Otherwise the intended spiral would be the same as a pieced elbow, all arms lying in one plane.

To be more specific, the positions of the throats are determined by the angle made by the axes of the two adjacent pieces as measured upon a plane at right angles to the axis of piece under consideration. A view or section in such a plane can be obtained by extending the axial line 3″ 4″ in either direction upon which any point, as *n*, may be assumed as the center of an end view. By extending 3 4, the corresponding line of the plan in both directions, it is discovered that the points 2 and 5 are back of the line 3 4—that is, back of a vertical plane represented by the line 3 4, a distance equal to *j* 2 or *k* 5. Therefore set off from point *n*, on 3″ 4″ extended, a distance equal to *j* 2 or *k* 5 as shown by the point *m* and through *m* draw a line at right angles as shown, representing a vertical plane. Lines projected from 2″ and 5″ of the elevation, parallel to 3″ 4″, to intersect the line through *m*, as shown at 2‴ and 5‴, will determine the angle between the axes of the two pieces adjacent to piece D. If now two circles the diameters of which are respectively equal to those marked 3 and 4 in the diagram of diameters be described from *n* as a center, their intersection with the lines *n* 2‴ and *n* 5‴, as shown at 3^a and 4^a, will represent the circumferential distance between the throat points at the two ends of piece D. In the case of a helical axis having an irregular fall, as before mentioned, the distances *j* 2 and *k* 5 would most likely be unequal, with the result that two points would be set off near *m* instead of one, when the line from point 2″ would fall into the line through one of the points, while the line from 3″ would fall into the line drawn through the other, and the points 2‴ and 5‴ would be thus located.

To obtain a view in the plane of the axes of the two pieces 3″ 4″ and 4″ 5″, which will give the true angle between them, first draw any line parallel to the axis 3″ 4″ and conveniently near, into which project lines from points 3″ and 4″ at

right angles to this axis as shown at r and s. On $r\ s$ extended at any convenient point as n' place a duplicate of the section at n so turned as to bring the line $n\ 5'''$ at right angles to $r\ s\ n'$ as shown by $n'\ 5^a$, which line will then represent a horizontal plane with reference to the view about to be constructed about the axis $r\ s$. The point 5″ of the elevation may now be located in this plane by the projection

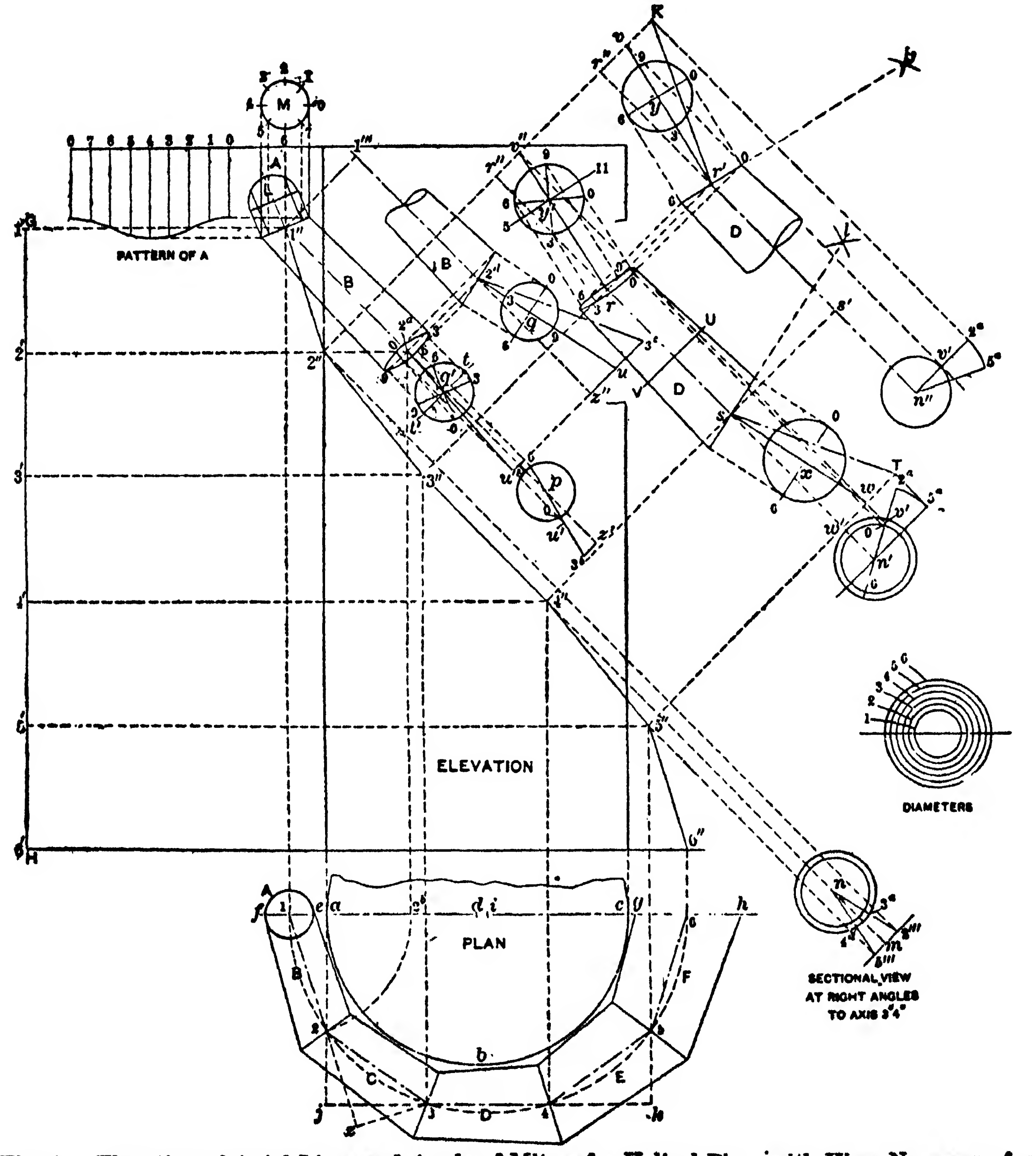


Fig. 4. Elevation of Axial Lines and Angle of Miters for Helical Pipe with View Necessary for Purpose of Triangulation

of a line to intersect a line from 5^a drawn parallel to $r\ s$ as shown at T. Then a line drawn from T to s will represent in this view the axis of the piece 4″ 5″ (which is shown at E of the plan), and the angle T $s\ r$ will be the true angle of the miter. To obtain the miter line, or line representing the miter plane, the bisecting of

this angle is only necessary, which can be most easily done by drawing from r and T as centers with any radius greater than $r\ s$, two arcs intersecting each other as shown at l. A line drawn from l through point s will then represent the desired miter plane.

This operation will have to be repeated with the axis 2″ 3″ to obtain the angle of the miter plane at the upper end of piece 3″ 4″. Since the axis 2″ 3″ does not lie in the same plane as that of the miter before shown, an additional view will have to be constructed, this time bringing the line n'' 2^a of the section at right angles to the axial line, all as shown still beyond the view just obtained, which for convenience may be termed an auxiliary view or projection. In this view r' s' is the axis obtained by continuing the lines previously drawn from 3″ and 4″, and a line is projected from 2^a of the section to meet a line from 2″ as shown at K, when K r' s' is the true angle of the upper miter, which is bisected as before by the arcs crossing at J, and J r' represents the miter plane.

Thus far the procedure was entirely by using the axes only of the several pieces. Before attempting the construction of such an elevation of any piece as may be used in developing its pattern, the nature of its profile or cross section must be considered. In the sections thus far shown the circle has been made use of merely as representing a true section. From this point in the solution of the problem, however, two courses are open to the draftsman, one of which may be termed the truly mathematical course, while the other offers an expedient whereby some labor may be saved. According to the first, a cross section of any piece on a plane at right angles to its axis, as for instance, that indicated by the line V U, is assumed naturally to be a circle, whence it follows that whether the piece be tapering or cylindrical, the sections on the miter planes must be elliptical, because they are oblique to the axis. According to the second course, it may be assumed that the section on the miter plane is a circle which conversely can exist only when the right or normal section (V U) of a piece is elliptical. Since the operations of triangulation impose no conditions upon the shapes of the two bases or ends of what are frequently termed transition pieces, by adopting the second course, the development of the ellipses mentioned in the first course is avoided, and also that of a right section mentioned in the latter course, since such section will serve no purpose. It may be remarked that the flattening of the pipe into an elliptical section at V U will cause very little change in its appearance, except the angle between any two pieces be made more acute than shown, as would be the case if the pipe passing around a semicircular plan were made in three or four pieces instead of five.

Having now determined the shape of the piece at its ends or miters, it now remains to complete such a view as will show the correct relative position of all points in both miters, such a view being required in the operations of triangulation in order that the exact lengths of all the elements of the surface, both primary and secondary, may be determined. In the case of the pipe of uniform diameter, the pattern would be obtained conjointly from the two views last obtained by setting off two stretchouts of the profile on a line at right angles to the axial lines $r\ s$ and $r'\ s'$, as toward J, taking care to place the point 0 of the upper stretchout at a distance from 0 of the lower stretchout, equal to that from 3^a to 4^a of profile n, the profiles at both ends being of course the same diameter. This will bring the throat points at the opposite ends of the piece in proper relation to each other in the pattern, thus insuring the proper twist of the spiral, after which points from profile n'' will be projected to the miter line at r', and thence into the measuring lines of the upper stretchout, while points from profile n' will be carried to the miter line at s, and thence into the lower stretchout.

In constructing the view for the purpose of triangulation above mentioned, it becomes necessary on account of different positions of the miter planes at the two ends to make a projection from points on the miter line at one end as at r' of the auxiliary view into the other or principal view, so as to obtain at r the correct position of the upper miter plane in its twisted position, thus bringing into that view all that is necessary for the purposes of triangulation. In order, first, that the points in the circumferences of both miter planes may be located upon the miter lines passing through s and r', it is necessary that their profiles should be so placed that their centers are on lines normal to those miter planes at their centers. Therefore, draw r', v and $s\ w$ at right angles, respectively, to those miter lines, and from any convenient points on them as y and x as centers, draw the profiles as shown. Lines drawn through those centers parallel respectively to the miter lines which they represent, will locate the points at the throat and the heel, as shown at 0 and 6 in both profiles.

To place a duplicate of the profile y in correct relation to the end of the principal view, so that the oblique view of the upper end or miter plane shown at r may be obtained by means of intersections from points on both profiles will perhaps be found the most difficult part of the entire problem. It can be accomplished by first obtaining the position of the line $r'\ v$ in the other view, as shown at $r\ v''$. In the rotation of this piece of pipe upon its axis, referred to above, it will be seen that, since the line 2″ K is at right angles to its axis, this line will represent a plane in which the points K and v would describe circles of which

the point r'', shown in both views, is the center. As explained above, the auxiliary view is a view in the plane shown by n'' 2^a of the profile n'', or by n $2'''$ of the profile n, and that the other or principal view is in the plane of n $5'''$ of the profile n, the plane of the view being shown in every case by the line drawn through the adjacent profile at right angles to the axis of rotation. Therefore, to transfer the point v from one view to the other first carry a line from v, parallel to the axis, to cut the line n'' 2^a, as shown at v', then transfer this point to the corresponding line of the profile n', as shown by v', and carry it thence by a line parallel to the axis to cut the line $2''$ K, as shown at v''. The line v'' r will then show the correct position of the line in question, upon which any point, as y', may be assumed as the center of the profile. The positions of the throat and heel in the miter may now be obtained by projecting lines from points 0 and 6 of profile n', parallel to the axis, to intersect lines drawn at right angles to the axis from 0 and 6 on the miter line r', which are obtained from profile y, as shown at 0 and 6 near r. These points may now be carried parallel to r v'' to cut the circumference of the profile y', as shown at 0 and 6. The profiles y and y' may now be spaced into the same number of equal spaces and the other points projected and intersected as explained in regard to the points 0 and 6, and as shown by 0, 3, 6 and 9, near r, the intermediate points being omitted on account of the necessarily small scale of the diagram. On account of the acuteness of the angle of intersection of the lines 0 0 and 6 6 with the profile y', there is great chance of error. As a means of verification it should be noted that the angle made by the intersection of the line 0 6 with the line 5 11 of profile y' should be equal to the angle made at n by the lines n $2'''$ and n $5'''$ of the first profile, this being the amount of rotation between the principal and the auxiliary view of this piece of the spiral pipe.

In reference to the statement made at the beginning regarding the difficulty of making a correct elevation and plan, it will now be seen how it is possible to make projections from the points obtained in the miters, as shown at r and s, back toward $3''$ and $4''$, to obtain a true front elevation, and, further, to extend those methods to also complete the plan. But as these operations are not essential to the development of the patterns they need not be described.

With the elevation of a piece completed as explained, the method of triangulating its surface will require some explanation since some unusual conditions occur. For this purpose in Fig. 5 is shown a view of the piece to a scale sufficiently larger to permit of points omitted in Fig. 4 being clearly shown. In this drawing the points of division in the profiles of both ends and the method of tri-

angulation are fully shown, but the miter line at r' of the auxiliary elevation of Fig. 4, from which projections are made to obtain the oblique view of the end r, is here omitted to make room for the diagrams of sections, with the hope that its use, though only partially shown, was there fully explained. Before beginning the construction of either diagram, it must be noted that as the result of the preceding operations the points of division at the two ends of the piece do not come numerically opposite, as they should be placed when conditions permit. In the latter arrangement points of like number at opposite ends are joined to form the primary elements, shown by the solid lines of the elevation, while points at one end are joined with those of the next higher number at the opposite end to form the secondary elements, shown by dotted lines. The method usually employed in obtaining the true lengths of the elements, in pieces of this general shape, is that of assuming a plane passing through the axis of the pipe as a base from which to measure hights at the two ends. Such a plane is, of course, parallel to the plane of the view and may be supposed to be the surface of the paper, one-half of the solid thus bisected being above the surface of the paper and one-half below. This plane is represented in the profile at the right by the line 0 x 6 and in that at the left by the line R y' S, both lines being at right angles to lines normal to the center of the miter planes, as explained above.

This method has been employed in diagram of secondary elements, which is constructed as follows: Draw any line, as T V, representing the plane of bisection, and at T erect a perpendicular, upon which set off the hight of all the points in the profile x as measured at right angles to the line 0 6. The distances of points below the bisecting line being equal to those above, three points on the perpendicular at T will thus represent all the hights in this profile, placing to each point all the numbers represented. From T, on T V, set off the lengths of all the secondary elements as measured on the elevation, placing the number of the point at the left end of the line, at the points as located, and at each point erect a perpendicular making its hight equal to that of corresponding number in the profile y' as measured above or below the bisecting line R S, all as shown above V in the diagram. It is advisable to repeat the numbers, as the several points are located at their proper hights, so that no mistake can be made in connecting these points properly with those on the perpendicular at T. Lines drawn from points on T to points at the left end corresponding with numbers connected in the elevation will then give the true lengths of the secondary elements.

Careful inspection of the profile y' will show that the point 11 at that end of the piece comes very nearly opposite point 0 at the right end, and therefore that

each point at the left will be just as nearly opposite to the point next higher in number at the right end. Being thus practically opposite, points at the left may be joined with those at the right in the following order to form the primary elements: 11 with 0, 0 with 1, 1 with 2, etc. Each primary being also practically in a plane with the axis of the pipe, the diagram for obtaining the true lengths of the primary elements may be very simply constructed by using the axis of the pipe as a base of the sections. The diagram thus becomes a series of radial sections folded or rotated into one plane, of which X Y is the base line. Therefore project lines at right angles to X Y from all points in both ends of the piece, cutting X Y and extending somewhat beyond. Since all the points in the miter at the small end are practically equidistant from the axis, draw a line across the perpendiculars at a distance from Y equal to the radius of the profile y', as shown at a, numbering the points of intersection with a to correspond with the points from which they are derived. For like reason draw the line b across the perpendiculars near X at a distance from X equal to the radius of profile x, numbering each point as before and as shown by the small figures. As all of the elements in this diagram would, if drawn, be practically one line, it is better to use the diagram without the line, simply finding the length of the element wanted by means of the figures at its ends as given on the elevation.

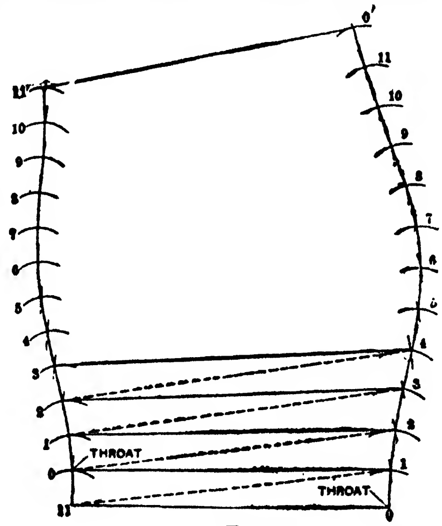


Fig. 6

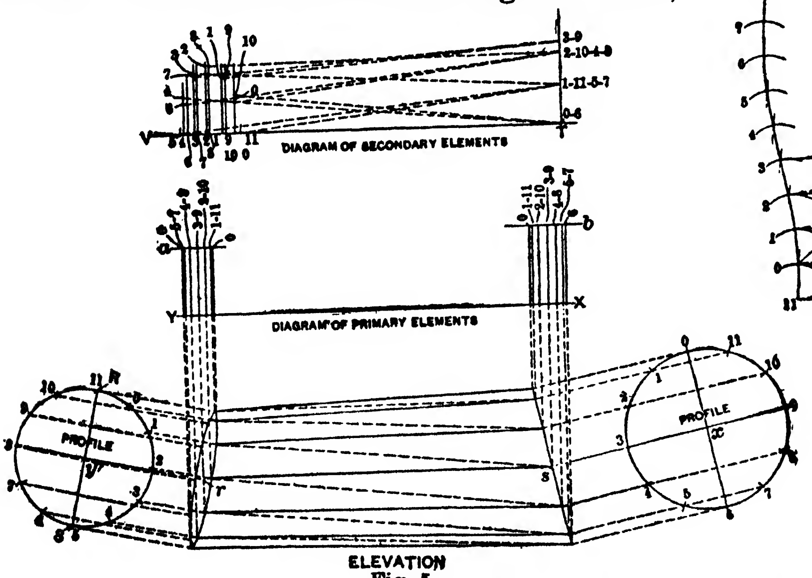


Fig. 5
Enlarged View of Middle Piece, Showing Method of Triangulation and Pattern

With the lengths of all the elements now obtained, the method of developing the pattern does not differ from that explained in the book in connection with

many similar cases and need not, therefore, be explained in detail. But on account of the unusual manner in which the numbers occur, it will be advisable to adopt some system of coupling the numbers whereby error may be avoided. Thus in beginning the pattern a line equal in length to 11 0, the first primary element is set off, when it will be noticed that the first secondary element is drawn from 11 at the left to 1 at the right end in the elevation and that it is set off from a point at the left in the pattern, so as to determine, in combination with the space 0 1 of profile x, the position of a point at the right which is two numbers higher; also that the following primary element is set off from a point at the right to locate, in combination with 11 0 of profile y', a point at the left which is one number lower. It will therefore be a great help to arrange the figures, by reference to the elevation, in the form shown in the two accompanying tables, in which the two numbers used to designate each element are coupled and placed in the order to be used as indicated by the words left and right:

TABLE OF NUMBERS TO BE JOINED FOR ELEMENTS

Primary				Secondary			
Right	Left	Right	Left	Left	Right	Left	Right
0	11	7	6	11	1	5	7
1	0	8	7	0	2	6	8
2	1	9	8	1	3	7	9
3	2	10	9	2	4	8	10
4	3	11	10	3	5	9	11
5	4	0	11	4	6	10	0
6	5						

The several elements can thus be taken from the diagrams by number as wanted and checked off the table as used. When the pattern has been completed, as shown in Fig. 6, the points marked 0 at the opposite sides will be the throat points in the two miters and will meet the points numbered 0 in miters of the adjacent pieces.

In proceeding with the work it will be necessary to repeat these operations as described for each of the pieces except for piece B. Since this piece miters with piece A at 1″ of the elevation at a sharp angle, the miter plane of its upper end is necessarily an ellipse. This makes the piece B a transition from an ellipse at one end to a perfect circle at the other. In beginning the work on this piece, its axis is brought into the plane of the view by carrying the point 2 of the plan around 1 as a center to 2^b on the center line of the plan, and projecting this point into the elevation to intersect the line from 2″, or 2′, as shown at 2^d. The axis of piece A being vertical, the position of the miter plane is found by bisecting the angle, as before explained and as shown at 1″.

The piece A being cylindrical instead of tapering, its pattern is obtained in the usual manner from points on its profile M, as shown at the left, and the points obtained on the miter line at 1″ in the operation are used in constructing the elliptical section L in the usual manner. The position of the miter plane at the upper end of piece B being thus fixed, and being also shown in the profile, it becomes necessary to obtain a view of the miter plane at its lower end, as seen in the plane of its axis. This is accomplished, as before, by means of an auxiliary elevation shown at B′, thus duplicating the operation performed at the upper end of piece D. At p is shown an end view of the lower part of piece B, in which $p\ z'$ is equal to z 3 of the plan and $z'\ 3^b$ equal to $m\ 5'''$, because the twist is the same at all the miters of the spiral from 2″ down. $2^d\ z''$ is equal to $s\ w'$ and $z''\ 3^c$ is equal to $p\ 3^b$. Thus $2^d\ 3^c$, the axis of piece 3, is brought into the same plane with $2^d\ 1'''$, the axis of piece B, when the angle at 2^d is bisected, giving the position of the miter plane of the auxiliary elevation. $2^d\ u$ is drawn normal to the miter plane on which is placed the profile q, of which 0 is the throat. Point u is transferred to a corresponding position on $p\ 3^b$, as shown by u', and carried parallel to the axis of B to intersect $3^c\ z''$ extended at u'', when the line $u''\ 2^d$ will represent the position of the normal in the principal elevation. On this last named line, from any convenient point as center, as q', draw a duplicate of profile q. Now from points 0 and 6 of profile p project lines to intersect lines from the throat and heel of the miter at 2^d, as shown at 0 and 6, near 2^d, and carry these points back to profile q', parallel to the normal 2^d, u'', cutting that profile, as shown at the points bearing the same numbers. With the throat and heel of the miter thus located on the two profiles q and q', the remaining points of division are easily found and the intersections made in an exactly similar manner to that explained above in regard to the profiles y and y', thus completing the elevation with respect to showing the lower miter plane in the twisted position necessary to produce the desired miter at 2″ of the elevation. In following the points down from profile M it will be noted that the throat of the upper miter will fall at t on the profile q', thus showing that the circumferential distance between the throat points at the two ends of the piece is more than 90 degrees; and further, that the line $t\ t'$ of profile q' represents the bisecting plane from which to measure hights in obtaining the diagrams of elements, all as explained in Fig. 5.

PATTERN FOR A FOUR-PRONGED FORK

Probably the best method to pursue in developing the pattern of this nature, to bring the ends of the several prongs to the required shape is to first cut a disc of

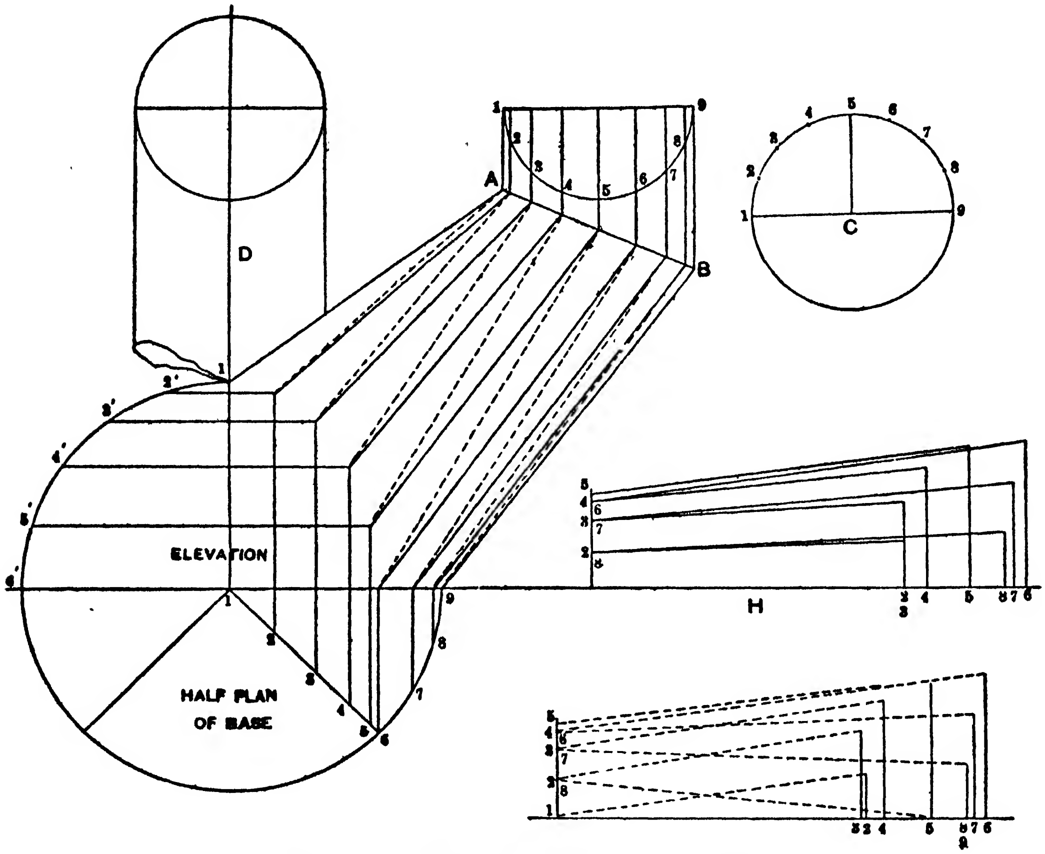


Fig. 7. An Obvious Solution of the Problem

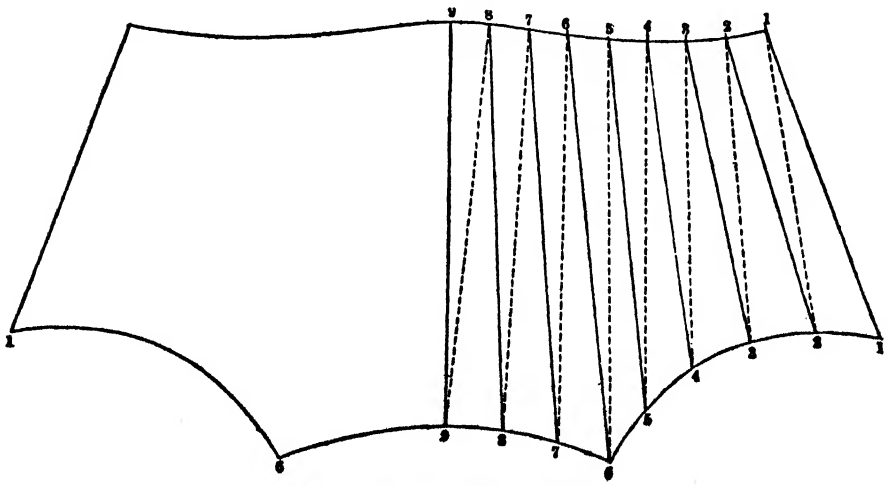


Fig. 8. Pattern Shape of Fig. 7

metal to the exact diameter of the plan of the large pipe, and then to bend two pieces of wire so as to form exact semicircles of the same diameter as the disc. The two wires, being crossed and fastened at right angles in the middle, may now have their ends soldered to the edge of the disc at four equi-distant points, when the templet thus formed will appear as in Fig. 9. Four spaces will thus be provided to receive the four prongs of the fork; and when the three points of one of the prongs indicated by 1, 6 of the pattern in Fig. 8 have been drawn apart till they reach the three angles of one of the openings of the templet the curves 1 6, 6 6 and 6 1 of the pattern must coincide with the corresponding curves of the templet, because in developing the pattern they have been made equal thereto. When the prong has been thus formed it will appear as in Fig. 10.

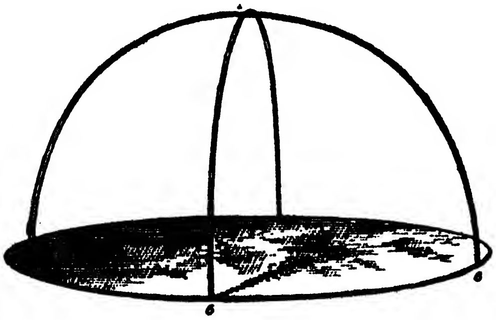


Fig. 9. Templet to Show the Shape of the Large Ends of the Prongs

The extra or fourth prong of the model, has been formed to its proper shape and its lines found to exactly coincide with such a templet and its angles of inclination to conform to that given in Fig. 7.

In applying the methods described to forks having a greater number of prongs than three, the method of establishing the joint line between adjacent prongs demands careful consideration. That the general section of the several prongs or branches, whatever be their number, should be as nearly round as possible throughout their course is quite a natural idea. In fact, the simplest solution to the problem that might suggest itself, before going into detail, is that of bringing together a number of prongs of a general conical form, by placing them radially about a common center and then cutting away as much of their sides as is necessary to form a miter joint between them, after the manner of a miter between cylindrical pipes. A miter formed between radial prongs cylindrical in shape would obviously result in a joint line greatly differing from the quarter circle 1 6′ of the elevation in Fig. 7, as will be shown. The methods

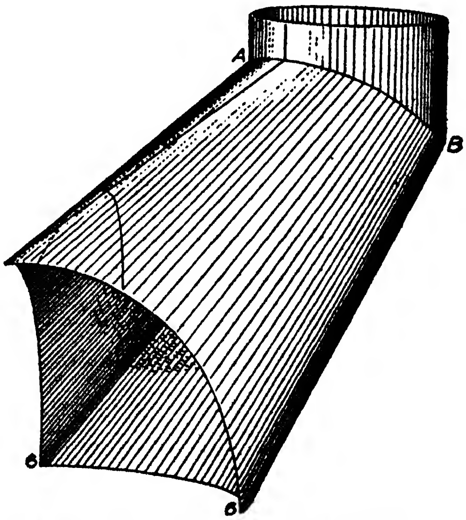


Fig. 10. Shape of One of the Branches of a Four-Pronged Fork

explained in the book can without doubt be extended to include any number of prongs and still satisfy the demands of capacity, since there is no technical reason for the large end of a prong, in the case of a four-pronged fork, having a greater capacity than one-fourth of that of the end of the large pipe.

Let it be supposed, for instance, that six prongs or branches are required. A templet constructed similarly to that shown in Fig. 9 to represent the junction of six branches would then have six arcs or wires descending from the apex 1 to six equi-distant points on the perimeter of the disc, when it will appear that while the sides of the openings still remain quarter circles as before, their lower arcs or outlines will be only sixths of a circle, thus narrowing the openings; and further that the openings would become narrower and more slot like as their number is increased, which would, if this method be adhered to, result in a corresponding flattening of the sides of the branches.

The operations of triangulation in their simplest form consist in developing the shape of a surface which when properly formed will constitute the side walls to inclose a space between two dissimilar and arbitrary forms the outlines of which can be properly termed the basis of the solid figure. Inasmuch as triangulation renders possible the use of arbitrary forms as bases, it thereby opens up the way to a great chance of error when it becomes necessary, as in the present case, to work to forms which are assumed instead of those which are the result of some other operation included in the solution of the problem. In the present case one base only is given in full, that shown by A B of Fig. 7. The other given base, the end of the large pipe, must be divided into as many equal arcs as there are branches required. On the above supposition that six are required, the sixth of the large circle can form only a part of the base of the larger end of a branch which must obviously also unite in part with the adjacent branches. In assuming any particular shape of outline as the remaining part of the required base the draftsman should be able to form a correct idea at the outset of what the result obtained therefrom will be; to see in his mind's eye, at least approximately, the shape of the resulting form in its entirety. This is an accomplishment that can scarcely be taught in books. It must be developed by exercise, by indulging the imagination, and by storing up a fund of knowledge which is the result of experience.

To maintain the rotundity therefore of the several branches at their junction with each other, a plan should first be drawn upon which the desired number of branches or prongs are shown, and each branch should be drawn with a taper approximately equal to that shown in its elevation. Fig. 11 gives the essential features of the parts. The plan of an additional prong is also shown in dotted

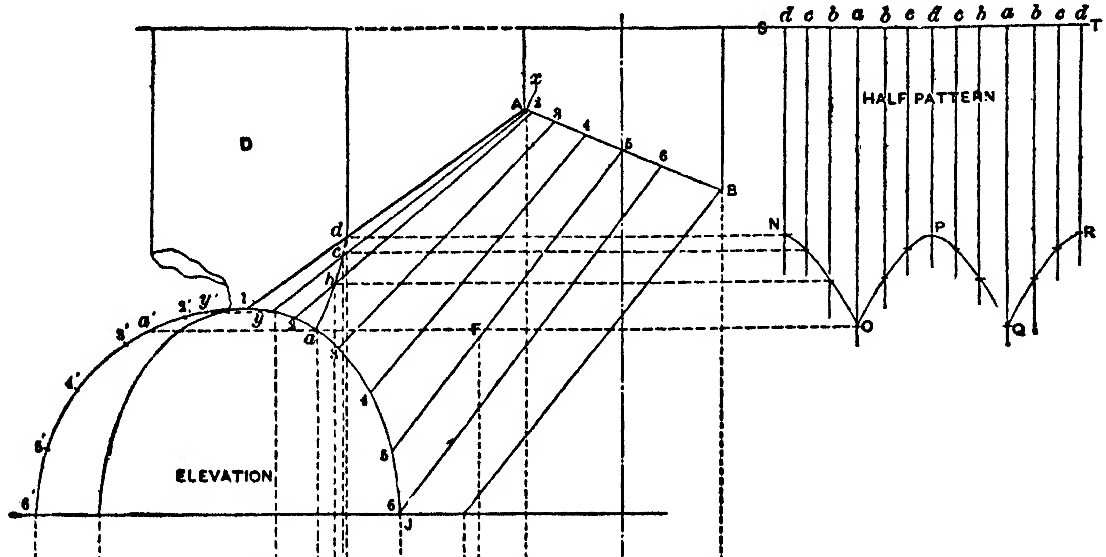
lines, its axial line being placed at an angle of 60 degrees from that of the other (as when six prongs are required), from which it will be seen that the sides of the prongs intersect each other at a point E, which is outside the circle of the large pipe. If a line be erected from E of the plan to intersect any line in the elevation of the prong which may be supposed to represent its greatest width, as for instance the line 5 5, it will be seen that the joint line between the prongs in the elevation must pass through this intersection, F, and must therefore be a much fuller curve than that originally assumed by the quarter circle 1 6′ in the elevation, Fig. 7. If the prongs of the fork were perfect cones or cylinders in form their lines could then be prolonged to the miter plane and the joint line developed in the usual manner, but since the form is irregular the draftsman is thrown upon his general knowledge of intersections to draw or design such a line as will pass from 1 through F to the point J of the elevation, Fig. 11.

The problem of a fork having any number of prongs can also be solved by constituting each branch a section of a perfect cone and extending its sides to intersect as they may with the miter planes 1 6 of the plan, and also with the sides of the large pipe, which would result in producing a mitered end on the large pipe.

To make this more interesting it is shown how to obtain the miter on the end of a small pipe to fit down over the intersection of the four prongs, as shown at D, Fig. 7, as well as the shape of the part to be cut from the pattern of the prong to form, when all are put together, the round hole to fit the mitered end of the pipe D. The first step is to draw a perfect plan of the prong, which shall include at least one set of the lines used in the elevation for the purpose of triangulation, all as shown in Fig. 11. Extend the center line of the short pipe above A B to cut the center line of the plan, as shown at C. From C, as center, describe the plan of the pipe to correspond with that above A B in Fig. 7, and divide it into the same number of spaces, as shown by the small figures. The points on 1 6 of the elevation and 1 6 of the plan are made duplicates of corresponding lines of Fig. 7. Now connect points of corresponding number in the plan, as shown by 2 2, 3 3, etc., thus obtaining lines upon the plan which exactly correspond with the solid lines in the elevation of the prong.

Now from G of the plan, as center, describe the plan of the central pipe D, as shown at D, cutting the several lines in the plan of the prong, as shown at *a* *b* and *d*. From these points erect lines into the elevation to cut lines of corresponding number, as shown by the same letters in that view. Should additional points be required in the miter, as for instance, in the space *b* *d*, bisect the spaces 1 2 of the plan C, and also of the line 1 6 in the plan D′, as shown at *x* and *y*, respectively, and

connect these points by the line crossing the plan D′ at *c*. Project points *x* and *y* into the elevation, as shown, draw *x y* of that view and erect a line from *c* of the plan to intersect line *x y* of the elevation, thus giving the additional point *c* in the elevation of the required miter.



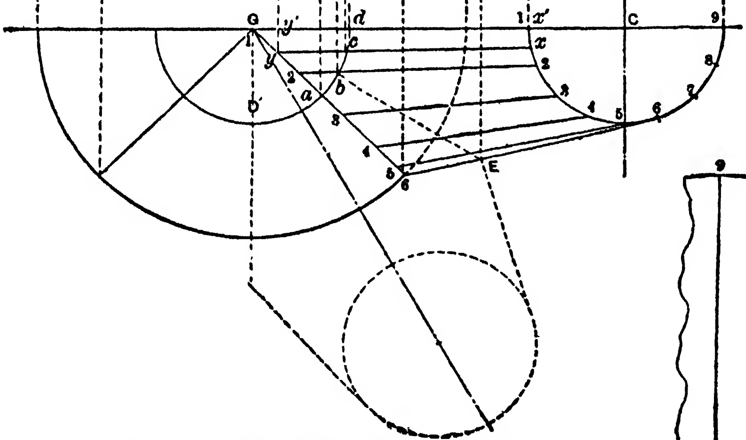


Fig. 11. Obtaining Pattern of Pipe D

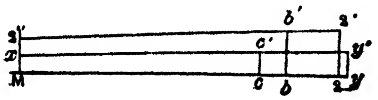


Fig. 12. Obtaining Points for Pattern, Fig. 13

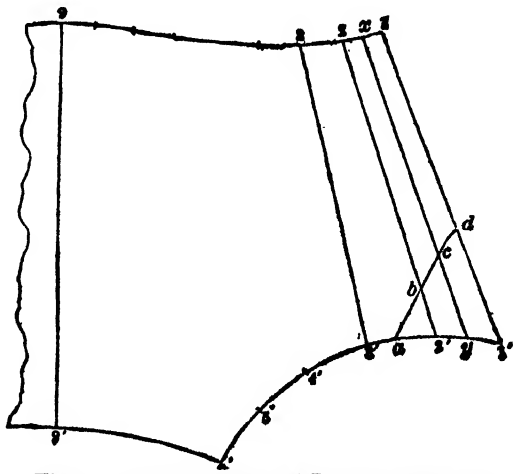


Fig. 13. Half Pattern of Prong, Showing Cut for Pipe D

The stretchout of the pipe D may now be taken from the several spaces between the points *a*, *b*, *c* and *d* on the plan D′ and set off on any line, as S T, drawn at right angles to the elevation, repeating the same as many times as is necessary to constitute the complete stretchout of the pipe, remembering that since the spaces in

D' are unequal it will be necessary to reverse their order in each alternate group, all as shown on S T, which is sufficient for a half pattern. Lines from the points a, b, c, d of the elevation may now be projected into the measuring lines of the stretchout, all as shown by dotted lines, thus developing the required pattern of D, one-half of which is shown by S, N, O, Q, R, T.

To obtain the pattern of the hole or in other words, the shape of the portion to be cut from the pattern of the prong, so that it shall meet the mitered end of pipe D, it will be necessary to set off the distances y c and 2 b of the plan Fig. 11, upon the base line of the diagram H, of Fig. 7, from which the true lengths of the solid lines of the elevation were obtained. Since, however, only one of the lines of this diagram is used, while an additional line, x y, has been introduced into the elevation, this operation is shown separately in Fig. 12, in which points $2'$ and 2 and lines connecting them are duplicates of corresponding parts of diagram H of Fig. 7. In Fig. 12 M $2''$ and M y are respectively equal to 2 2 and x y of the elevation, Fig. 11. Now from y of Fig. 12 set off on y M the distance y c, equal to y c of the elevation, Fig. 11; and from 2 on 2 M the distance $2''$ b', equal to 2 b of the elevation. At y erect a line y y', equal to y y of the plan, Fig. 11, and at M make M x equal to x x' of the plan. Draw y' x of Fig. 12, and from c erect a line cutting the same at c'; then from y of the pattern, Fig. 13, set off on y x the distance y' c' of Fig. 12, and also make $2'$ b of the pattern equal to $2'$ b' of Fig. 12.

The distance $1'$ d of the pattern is of course equal to 1 d of the elevation, while the position of the point a of the pattern is obtained by first projecting the point a of the elevation to the profile of the joint line 1 $6'$ at the left, as shown thereon at a', when its distance from either adjacent point may be set off from the corresponding point on the line $1'$ $6'$ of the pattern. A line traced through the points a, b, c and d of the pattern will show the shape of the piece (a d $1'$) to be cut from the pattern to insure a miter with the pattern of the pipe D. The position of point y upon the pattern is obtained by a projection to the the left from y of the elevation to line 1 $6'$, as shown at y', etc., all as explained in regard to point a, while the position of x must be obtained by measurement from an adjacent point on a true section on A B, if such section is developed or on the miter pattern of the connecting piece, as explained above. Its position on the plan C of Fig. 11 is, however, sufficiently accurate to serve the present purpose.

An inspection of the pattern of the pipe D, as shown in Fig. 11, will now show that its shape corroborates the statement above made with reference to the triangular shape of the large end of the prong, as shown in Figs. 9 add 10. Since the

prong is nearly round at A B of Figs. 7, 10 and 11, and quite angular at point 1, its shape at *d* of Figs. 10 and 11, which is about one-third of the way up from point 1, can easily be conceived to be that shown at P of the pattern in Fig. 11.

SQUARE TO ROUND TWISTED ELBOW PATTERNS

In this solution it is well to state that the principles as here outlined are applicable to any number of pieces and for this example a four-piece elbow was taken. This is a 90-deg. elbow twisting from square to round as shown by the perspective Fig. 14.

In Fig. 15 let I II III IV represent the side elevation of the four-piece twisted elbow with an angle of 90 deg. as shown, the miter or joint lines *a b*, *c d* and *e f* being drawn toward the center H°. The two end pieces of the patterns will be developed by parallel lines and the two middle pieces by triangulation.

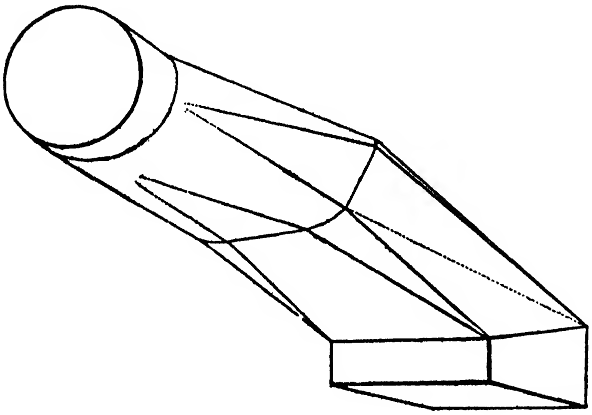


Fig. 14. Model of the Completed Twisted Elbow

In this case assume that the miter lines *a b*, *c d* and *e f* remain fixed lines, representing the miter planes when the elbow is viewed from the side. From these planes the miter lines shown in the front elevation are then projected. By using this method of establishing straight lines in the side elevation as the miter planes considerable time is saved when developing the patterns, because no true angles need be found, and the various operations in projections needed in connection with the true angles can be dispensed with.

Having drawn the side elevation of the elbow, bisect the miter lines 1 5, 6 11 and 12 13 and obtain the points 3, B and C respectively. Through these points draw the center line of the elbow shown by the heavy dotted line from A to D. Extend the line 3 A indefinitely to the left, upon which establish the point A^3 representing the center of the round pipe. Using A 1 or A 5 in the side elevation as radius and A^3 as center, draw the circle 1 3 5 3′ representing the front view of the upper piece of the elbow marked I in the side elevation, when it is twisted and turned toward the reader.

From the center A^3 draw a vertical line until it intersects the line D H° extended from the side elevation at J. At pleasure establish the distance J D° in the front elevation, which in this case has been made equal to J A^3. As the elbow has two pieces between the top and bottom pieces, as shown in the side ele-

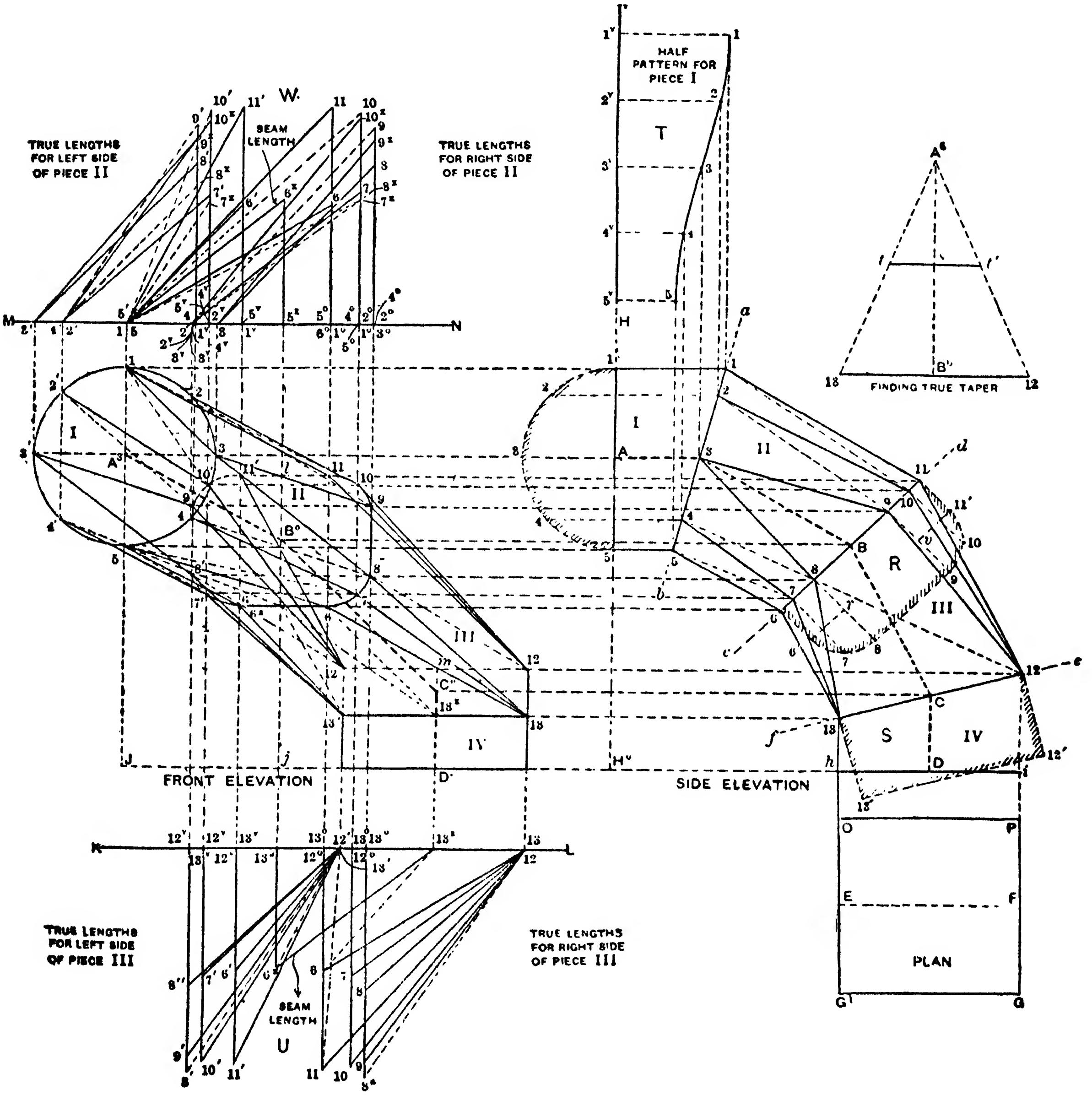


Fig. 15. Elevations, Plan, Diagram of Triangles, Pattern and True Taper

vation, divide the space between J and D° in the front elevation in two parts as shown by *j*, and from *j* and D° erect vertical lines until they intersect horizontal lines drawn from B and C in the side elevation at B° and C° respectively in the front elevation. Trace the heavy dotted line as shown from A^3 to B° to C° to

D° which represents the center line of the elbow in the front elevation shown by similar letters A 3 B C and D in the side elevation.

Whatever number of pieces are contained in the elbow between the top and bottom pieces in the side elevation, that number should be divided between J and D° in the front elevation, so as to establish the center line of the elbow in that view. Thus if a six-pieced elbow is used, the space between J and D° would be divided in four parts, which is the number of spaces contained between the top and bottom pieces.

With A in the side elevation as center, and A 1 as radius draw the semicircle shown, which divide into an equal number of spaces, in this case four as shown from 1 to 5. In similar manner divide the circle I in the front elevation in similar number of spaces as shown from 1 to 3 to 5 to 3′ to 1. This semisection 1 3 5 in the side elevation represents the half profile for piece I of the elbow. Below the line *h i* of piece number IV draw the section of the square pipe as shown by O P G G^1, which represents the profile for piece IV.

As the pieces I and IV will be developed by parallel lines, these two patterns will be laid out first. Extend the line 5 1 as shown by H I, upon which place the girth of the semi-section of the round pipe, as shown by the small figures 1^v to 5^v. At right angles to H I through the small figures draw lines, which intersect by lines drawn parallel to H I from similar numbered intersections on the miter line *a b*, which were previously obtained by drawing lines at right angles to 1 5 from the small figures in the semicircle. A line is traced through points thus obtained as shown by the small figures 1 to 5 in T. Then will 1^v 1 5 5^v be the half pattern for piece number I.

For the half pattern for piece number IV, take the girth of the half-square section F P O E, and place it upon the horizontal line A^3 B^3, as shown by F° P° O° E°, and through these points erect perpendicular lines to A^3 B^3 as shown. Measuring from the line *h i* in the side elevation, take the hights to points 12 and 13 on the miter line *f e* and place them in the pattern on corresponding lines measuring in each instance from the line A^3 B^3, obtaining the points 12, 12′, 13′, 13 respectively. Trace a line through points thus obtained. Then will E°, 13, 12, F° be the half pattern desired.

The next step is to obtain the true sections on the miter lines *e f* and *c d*. No true section need be found on the miter line *a b* because the piece I lies in a horizontal line, so that when the miter line *a b* is viewed from the front it will show a true circle as indicated by I in the front elevation. If, however, the piece I in the side elevation were other than in a horizontal position, the front view of

the miter would show an elliptical shape and would be obtained in a manner similar to that which will be explained in connection with obtaining the front view of the miter line 6 11 in the side elevation.

As the elbow runs from square to round, a proportional taper must be found between the square end of piece IV and the round end of piece I. This taper from the square end to the round end is shown by 3, 9, 12, 13, 8, 3 in the side elevation and is found as follows: Draw a vertical line of any length as A^6 B^6, at right angles to which draw the line 12 13, making B^6 12 and B^6 13 equal to the miter lines C 12 and C 13 respectively. From 12 and 13 in the true taper, draw lines to the apex A^6. The elbow having two middle pieces, divide the line A^6 B^6 in two parts as shown by *s*, through which draw the horizontal line cutting the sides of the triangle at *t* and *t′*. Then *s t* or *s t′* is placed from B to 8 and B to 9 in the side elevation and lines drawn from 3 to 9 to 12 and from 3 to 8 to 13.

As the pipe is a true square at one end, this same taper applies to the top and bottom of the elbow as well as the sides. This taper along the bottom and top of the elbow is shown in the front elevation and is projected to that view as will be described. The true taper being known the true section on the miter line *c d* is found as follows: At right angles to *c d* from points 6, 8, 9 and 11 erect perpendicular lines, making the distances 6 6′ and 11 11′ equal to *s t* in the true taper and the distances 8 8 and 9 9 in the side elevation equal to the full width *t t′* in the true taper. From 6′ and 11′ in the side elevation, parallel to *c d*, draw lines intersecting the lines 8 8 and 9 9 at *r* and *v* respectively. Using *r* and *v* as centers, with a radius equal to *r* 6′, or *v* 11′, draw the quarter circles shown by 6′, 8 and 11′, 9 respectively. Then will 6, 6′, 8, 9, 11′, 11 be the half true section on the miter line *c d*.

To find the true section on the miter line *f e*, draw lines from points 12 and 13 at right angles to *f e*, as shown by 12, 12′ and 13, 13′ both equal to the half width of the square pipe shown by O E or P F in plan. Draw a line from 12′ to 13′. Then will 12, 13, 13′, 12′ be the half true section on the miter line *f e*.

As the quarter section A 1 3 of piece I is divided into two equal spaces, divide the quarter circles in the half section on *c d*, also each into two parts as shown by points 7 and 10, from which points at right angles to *c d* draw lines intersecting the miter line *c d* at 7 and 10 respectively. Connect the various points on the miter lines *a b*, *c d* and *e f* as follows: Draw lines from 4 to 7 to 13; from 3 to 8 to 13; from 3 to 9 to 12; from 2 to 10 to 12; also dotted lines from 5 to 7, 4 to 8, 2 to 9 and 1 to 10. These lines represent the bases of the triangles which will be constructed later on.

The next step is to draw a correct view of the front elevation, showing the true position of the miter lines *c d* and *e f* in the side elevation. Therefore, from points 12 and 13 on the joint line *f e* in the side elevation draw horizontal lines in the front elevation, indefinitely as shown. Extend the center line D° C° in the front elevation as shown by D° *m*. Measuring from this line *m* D°, set off the distances *m* 12, *m* 12′, 13^x 13 and 13^x 13′ equal to the half width of the square pipe shown by D *h* or D *i* in the side elevation. Draw lines from 12 to 13 to 13′ to 12′ to 12, which represents the front view of the miter line 12 13 in the side elevation.

In a similar manner from points 7, 8, 9 and 10, on the miter line *c d* in the side elevation draw horizontal lines to the front elevation indefinitely as shown, and through the intersection B° extend the line *j* B° as B° *l*. Measuring from the line *c d* in the side elevation, take the various distances to points 6′, 7, 8, 9, 10 and 11′ and place them in the front elevation on similar lines previously drawn, on either side of the center line *l* 6^x, thus obtaining the points of intersections from 6 to 11 on the right and from 6′ to 11′ on the left. A line traced through these points as shown will be the miter line in the front elevation on the line 6 11 in the side. Connect the various points in the front elevation as follows: 6, 7 and 8 to 13; 9, 10 and 11 to 12; 6′, 7′ and 8′ to 13′ and 9′, 10′ and 11′ to 12′, which is similar to the connections shown in piece III in the side elevation. Connect the various points in piece II in the front elevation by drawing solid lines from 1 to 11, 2 to 10, 3 to 9, 3 to 8, 4 to 7, 5 to 6; 5 to 6′, 4′ to 7′, 3′ to 8′; 3′ to 9′, 3′ to 10′ and 1 to 11′. Also draw dotted lines from 1 to 10, 2 to 9; 4 to 8, 5 to 7; 5 to 7′, 4′ to 8′; 2′ to 9′ and 1 to 10′, which represent similar connections shown in piece II in the side elevation.

As the seam will be placed in the throat of the elbow, bisect 6 6′ and 13 13′ in the front elevation as shown respectively by 6^x and 13^x and draw the seam line 5 to 6^x to 13^x as shown. The horizontal distances between the various points shown in the miter lines in the front elevation represent the altitudes of triangles, which must now be constructed as follows: Through the various intersections in the lower and center miter lines in the front elevation, drop vertical lines indefinitely as shown. In a similar manner through the various intersections in the center miter line, as well as through the points in the profile of the upper arm, erect vertical lines indefinitely, as also shown. At pleasure, below the front elevation, draw a horizontal line as K L, and in a similar manner above the front elevation draw another horizontal line as M N. To find the true lengths of the lines shown in piece III in both front and side elevation take the various dis-

tances from 13 to 6, 13 to 7 and 13 to 8 in the side elevation and place them on lines dropped from points 6, 7, 8, 6′, 7′ and 8′ in the miter line in the front elevation, measuring in each instance from and below the line K L, as shown respectively from 13° to 6, 13° to 7, 13° to 8, also from 13^{v} to 8″, 13^{v} to 7′ and 13^{v} to 6′. At right angles to K L from points 13 and 13′ in the miter line, drop lines intersecting the line K L at 13 and 13′ respectively, and from the point 13 just obtained in diagram U, draw lines to 6, 7 and 8, and from 13′ draw lines to 6′, 7′ and 8″. These lines represent the true lengths of lines shown by similar numbers in piece III in the side or front elevation.

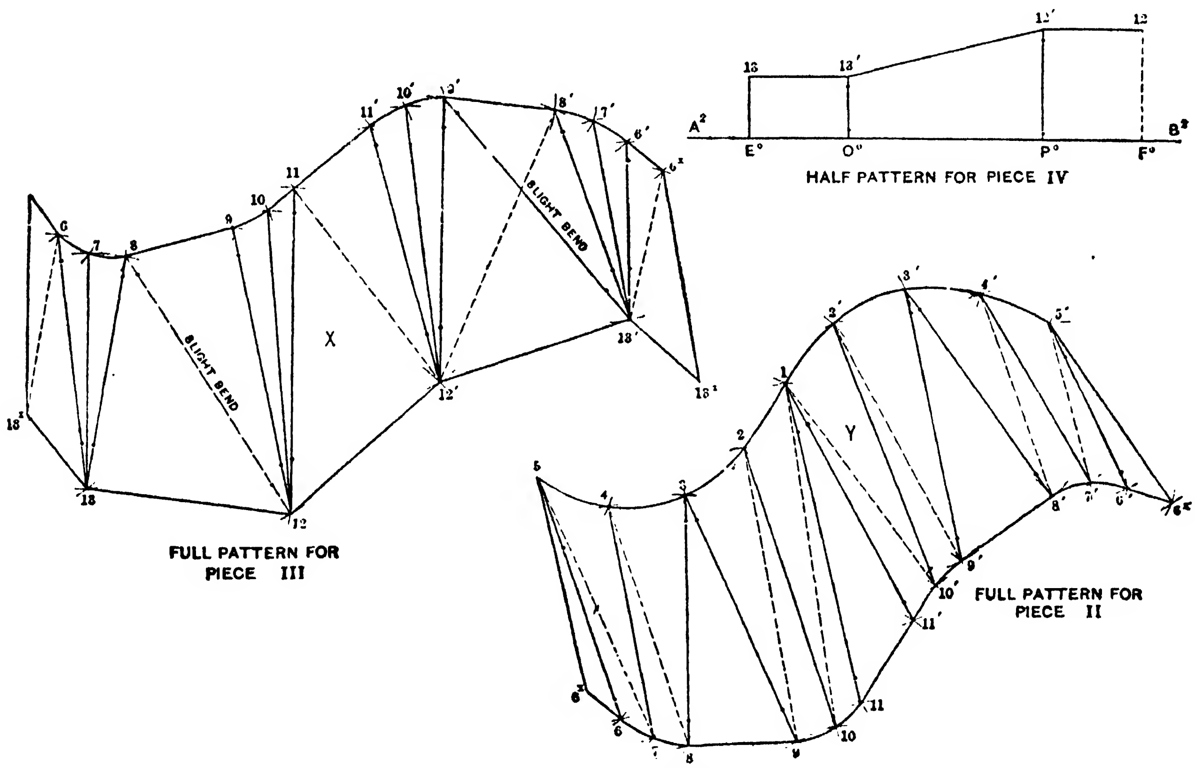


Fig. 16. Patterns for the Various Parts

In a similar manner take the various distances in piece III in the side elevation, from 12 to 9, 12 to 10 and 12 to 11, and place them on lines dropped from 9, 10 and 11, also from 9′, 10′ and 11′ in the miter line in the front elevation, measuring in each instance below the line K L, as shown respectively from 12° to 9, 12° to 10 and 12° to 11, also from 12^{v} to 9′, 12^{v} to 10′ and 12^{v} to 11′, and draw the slant lines from 9, 10 and 11 to point 12, and from points 9′, 10′ and 11′ to point 12′, both points 12 and 12′ being upon the line K L, having been previously obtained by lines dropped from points 12 and 12′ respectively in the miter line in the front elevation. These slant lines just drawn

in diagram U then represent the true lengths of similar numbered lines shown in piece III in the front or side elevation. Further procedure would be to find the true length of the dotted line shown from 8 to 12 in piece III in the side elevation, accordingly the distance from 8 to 12 is taken and setting it off on lines dropped from 8 and 8′ in the miter line in the front elevation, as shown respectively from 12° to 8^{a} and from 12^{v} to 8′ and draw lines from 8′ to 12′ and from 8^{a} to 12, which represents the true length of similar numbered lines shown from 8′ to 12′ and 8 to 12 in the front elevaion.

Before the patterns for the flat surface 11, 11′, 12′, 12 in piece III in the front elevation can be obtained, the true length on the dotted line drawn from 11 to 12′ must first be ascertained, by taking the distance from 11 to 12 in the side elevation and placing it as shown from 12° to 11 in diagram U and drawing a line from 11 to 12′. This slant line then shows the true length of the line 11, 12′ in the front elevation.

And, in a similar manner before the pattern for the flat surface 6′, 6, 13, 13′ shown in piece III in the front elevation can be obtained, the true lengths of the seam line 6^{x}, 13^{x}, and lines drawn from 6 to $13^{x\prime}$, and 6 to 13^{x} must first be ascertained as follows: Take the distance from 6 to 13 in the side elevation and place it in diagram U, as shown, respectively, from 13^{a} to 6^{x}, 13^{v} to 6′ and 13° to 6, and draw slant lines from 6^{x} to 13^{x}, 6′ to 13′ and 6 to 13^{x}, representing, respectively, the true lengths of lines shown by similar numbers in piece III in the front elevation.

Possessing all the necessary data by the methods explained in the foregoing, the operation now is to obtain the true lengths of the various lines shown in piece II in the side elevation. From the various intersections 1, 2, 3, 4, 5, 4′, 3′, 2′ in the circle shown in the front elevation, lines are erected until they intersect the line M N as shown by similar figures. Take next the various distances of 5 6, 4 7 and 3 8 in the side elevation and place them upon lines drawn from points 6, 7 and 8, also points 6′, 7′ and 8′ in the miter line in the front elevation, measuring from the line M N in diagram W, as shown, respectively, from 5° to 6, 4° to 7 and 3° to 8, also from 5^{v} to 6′, 4^{v} to 7′ and 3^{v} to 8′ and draw slant lines from 6 to 5, 7 to 4 and 8 to 3, also from 6′ to 5, 7′ to 4′ and 8′ to 3′. These lines represent the true lengths of lines having similar numbers in piece II in the elevations.

Again take the distances of 3 9, 2 10 and 1 11 in piece II in the side elevation, and place them, measuring from the line M N, upon lines drawn from points 9, 10 and 11, also 9′, 10′ and 11′ in the miter line in the front elevation

as shown, respectively, by the distances from 3° to 9^x, 2° to 10^x and 1° to 11, also from 3^v to 9^x, 2^v to 10^x and 1^v to 11′, and draw slant lines from 9^x to 3, 10^x to 2 and 11 to 1, also from 9^x to 3′, 10^x to 2′ and 11′ to 1, which show the true lengths of similar numbered lines in piece II. Having carefully followed the aforesaid instruction, watching particularly the secondary indices, finally take the length of the dotted lines in the side elevation, from 5 to 7, 4 to 8, 2 to 9 and 1 to 10 and place them, measuring from the line M N, upon lines drawn from points 7, 8, 9 and 10, also points 7′, 8′, 9′ and 10′ in the miter line in the front elevation, as shown by the distances 5° to 7^x, 4° to 8^x, 2° to 9 and 1° to 10, also from 5^v to 7^x, 4^v to 8^x, 2^v to 9′ and 1^v to 10′, and draw slant lines from 7^x to 5, 8^x to 4, 9 to 2 and 10 to 1, also from 7^x to 5′, 8^x to 4′, 9′ to 2′ and 10′ to 1, which lines show the true distance of similar numbered lines in the front or side elevation.

As the seam line is shown by 5 6^x in piece II in the front elevation, to find this true length take the distance of 5 6 in the side elevation and place it on the line erected from 6^x in the front elevation, as shown in diagram W, from 5^x to 6^x and draw a slant line from 6^x to 5, which is the true length desired. All of the true lengths having been found, the patterns are now in order. To develop the pattern for piece II proceed as follows: Take the distance of 5 6^x in diagram W and place it upon the line drawn in Y as shown by 5 6^x. With 6 6′ in the semi-section R in the side elevation as radius and 6^x in Y as center, draw the arc 6, which intersect by an arc struck from 5 as center and 5 6 in W as radius. Again with 6′ 7 in the semi-section R in the side elevation as radius and 6 in Y as center, describe the arc 7, which intersect by an arc struck from 5 as center and 5 7^x in the diagram W as radius. Now using the division 5 4 in the miter cut in the half pattern T as radius and 5 in the pattern Y as center, draw the arc 4, which intersect by an arc struck from 7 as center and 7 4 in diagram W as radius.

Proceed in this manner, using alternately, first the divisions in the semi-profile R in the side elevation, then the proper true length in diagram W; the divisions along the miter cut in T, then the proper length slant line in W until the line 1 11 in pattern Y has been obtained. Then with a radius equal to twice the distance of 11 11′ in the semi-section R in the side elevation, and 11 in pattern Y as center, describe the arc 11′ and draw a line from 11′ to 1. Now again proceed as before, using alternately, first the divisions of the proper number in the semi-section R, then the proper true length in the diagram W; the proper division along the miter cut in T, then the proper true length in W, until the line 5′

$6'$ in pattern Y has been obtained. Then using $6\ 6'$ in the semi-section R as radius, and $6'$ in the pattern Y as center, describe the arc 6^x, which intersect by an arc struck from $5'$ as center and $5\ 6^x$ in W as radius. A line traced through points thus obtained in the pattern Y, as shown from 5 to 1 to $5'$ to 6^x to $11'$ to 11 to 6^x to 5, will be the pattern for piece II of the elbow, to which edges must be allowed for seaming purpose.

For the pattern for piece number III, Fig. 16, draw any line as $6^x\ 13^x$ in X equal in length to the seam length $6^x\ 13^x$ in diagram U. In this case, instead of using the divisions in the semi-sections R in the side elevation as radius, use the divisions along the lower cut 6^x to 6^x of the pattern Y, which were previously taken from R, and therefore are the same. Then with $6^x\ 6$ in Y as radius and 6^x in X as center, draw the arc 6, which intersect by an arc struck from 13^x as center and $13^x\ 6$ in diagram U as radius. With $13\ 13'$ in the semi-section S or $13\ 13'$ in the half pattern for piece IV as radius and 13^x in the pattern X as center, describe the arc 13, which intersect by an arc struck from 6 as center, and 6 13 in diagram U as radius. With radii equal to 13 7 and 13 8 in diagram U, and 13 in the pattern X as center, describe the arcs 7 and 8. Set the dividers equal to the spaces 6 7 and 7 8 in Y and step from arc 6 to arc 7 to arc 8 in X. Now with $13'\ 12'$ in either the semi-section S or the half pattern for piece IV as radius, and 13 in the pattern X as center, describe the arc 12, which intersect by an arc struck from 8 as center and $8^a\ 12$ in diagram U as radius.

Proceed in this manner, using alternately, first the divisions along the lower cut of pattern Y, then the proper slant line in diagram U, until the line 11 12 in pattern X has been drawn. Then take as a radius, twice the distance of $12\ 12'$ in diagram S in the side elevation, or the distance of P G in the plan, which is the same and with 12 in X as center describe the arc $12'$, which intersect by an arc struck from 11 as center and $11\ 12'$ in diagram U as radius. Now proceed as before, using alternately, first the divisions in the lower cut of the pattern Y, then the proper slant line in diagram U; the divisions in the semi-section S or the half pattern for piece IV, both divisions being similar, then again the proper slant line in diagram U, until the line $6^x\ 13^x$ in the pattern X has been obtained, which must be similar to the seam line on the opposite end of the pattern.

A line traced through points thus obtained as shown from 6^x to 6 to 11 to 11 to $6'$ to 6^x to 13^x to $13'$ to $12'$ to 12 to 13 to 13^x to 6^x, will be the pattern for piece III, Fig. 16, of the twisted elbow. Laps must be allowed on the pattern for seaming purposes. In forming up pattern for piece III, Fig. 16, slight bends must be made along 8 12 and $9'\ 13'$ as indicated on the pattern.

PATTERNS FOR TRANSITION PIECE INTERSECTING CONE

The following instructions are for the proper method of laying out the patterns for a separator involving its intersection by a transition piece, changing from round to a rhomboid, the sides of which run parallel to the top and sides of the main funnel or cone.

Referring to the accompanying diagrams, Fig. 17, let A B represent the center line of the funnel or cone and C D E F the elevation. At a point below the elevation in its proper relative position with G on the center line as center, draw the plan H J and L M, representing respectively the sections through C D and E F of the elevation. In its proper position draw the rhomboid shown in elevation by 1 2 4 5. This represents the elevation of the transition piece where it intersects the cone. Draw also the circle *a c e g* in its proper position, which represents a section of the transition piece at the outer end indicated by *c g* in plan.

The first step is to find the miter line showing the line of intersection between the rhomboid and funnel in plan. To do this draw horizontal planes through 1 2 and 4 5 in elevation; also establish another plane between 1 and 5, as shown by 3 6.

In practice, more planes must be employed to obtain an accurate pattern, but only three planes are used in this case, to show the principles employed.

Extend the planes 2 1, 3 6 and 4 5 until they intersect the side of the cone C F at 1′ 2′, 3′ 6′ and 4′ 5′, from which intersections vertical lines are drawn to the plan intersecting the horizontal line *i j* drawn through the center, G in plan, as shown by similar numbers. Then using G as center, with radii equal to G 1′, 3′ and 4′, draw the circles shown, which represent the various planes in plan. Now from the intersections 1, 2, 3, 4, 5 and 6 in the rhomboid in elevation, drop perpendicular lines in the plan, intersecting similar numbered planes, as shown by similar numbers, through which trace the miter line as shown. Establish at its proper distance from the center line *i j*, the line *c g*, upon which obtain the intersections, *c*, *g*, *c*, *d*, *b a e*, *h f* and *g*, by dropping perpendiculars from similar lettered intersections in the circle in elevation, all as shown by the dotted lines.

Now connect the various points in the rhomboid and circle both in plan and elevation as follows: Connect 1 and 2 to *a*; 5 and 4 to *e*; 5, 6 and 1 to C; 4, 3 and 2 to *g*; *h* to 2; *f* to 4; *b* to 1, and *d* to 5.

Then will the lines in plan represent the base lines of triangles which will be constructed in X, with altitudes equal to the various hights between similar numbers and letters in elevation. As 1, 2 and *a* in elevation lie in one plane. then

will 1, 2 and *a* in plan show the true pattern for that part. As *e* in elevation lies above the plane 5·4, establish another point between 5 and 4 as shown by 7, and drop a perpendicular line in plan, intersecting the plane 4′ 5′ in plan at 7. Connect

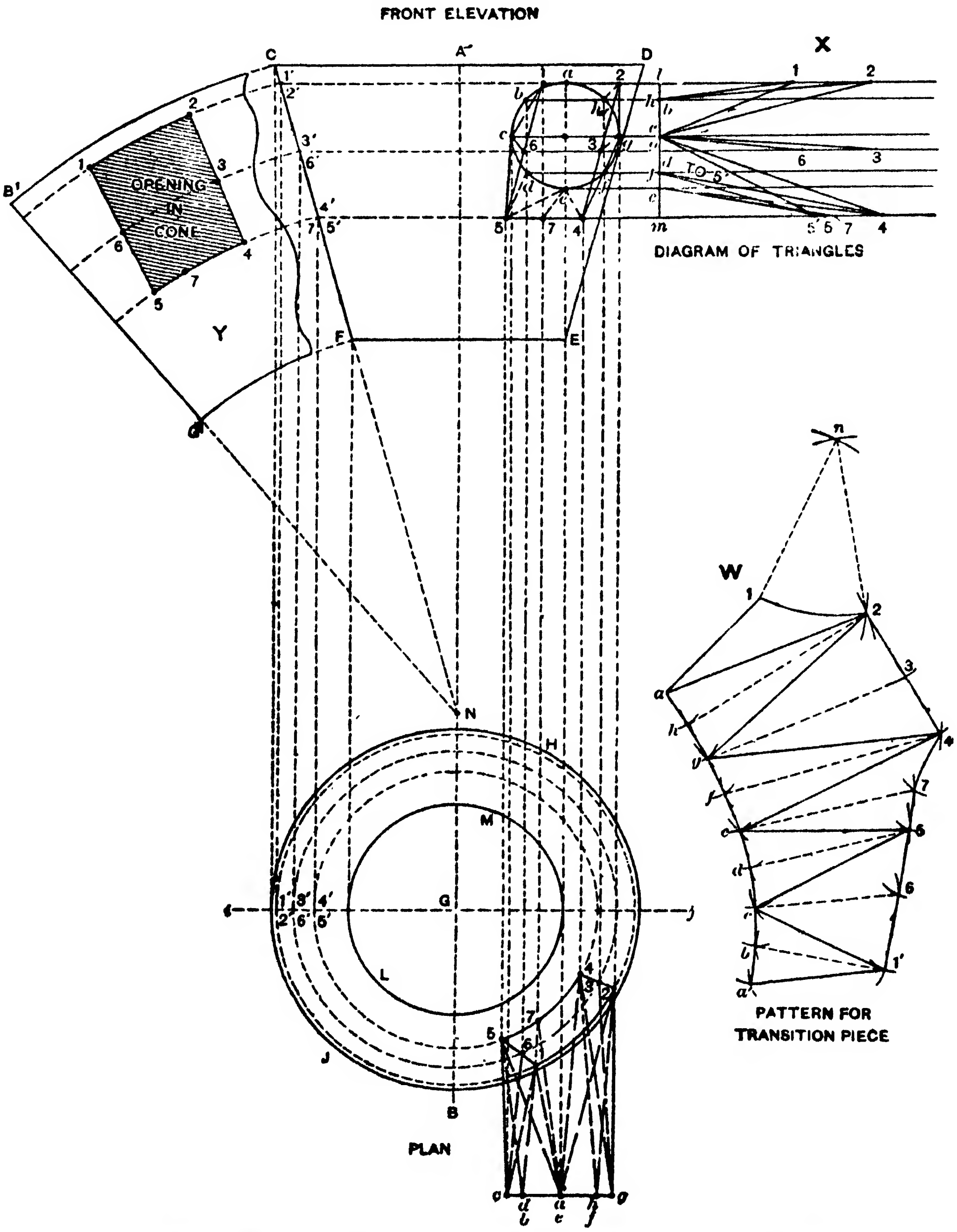


Fig. 17. Complete Process for Obtaining Patterns of Transition Piece Intersecting a Cone.

the point 7 to *e*, both in plan and elevation. From the various points in the circle and rhomboid in elevation, draw horizontal lines to the right as shown, perpendicular to which draw the line *l m*.

To obtain the various true lengths of the lines shown in plan, three examples will be given. Thus, to obtain the true lengths of the lines *e* 5 and *e* 4 in elevation, take the distances of *e* 5 and *e* 4 in plan and place them in X, measuring from the line *l m*, as shown by 5 and 4 on the line drawn through 5 7 4 in elevation. From 5 and 4 in X draw lines to where the horizontal line drawn from *e* in elevation intersects the line *l m* at *e*. Then will *e* 4 and *e* 5 in X represent the true length of *e* 4 and *e* 5 in plan or elevation.

Again to obtain the true length of 5 *d* in plan or elevation, take the length of 5 *d* in plan and place it as shown from *m* to 5′ in X, and draw a line from 5′ to *d*, on the line *l m*, being the intersection where the horizontal line drawn through *d* in elevation intersects *l m*. Then will *d* 5′ be the true length of *d* 5 in plan or elevation. In this manner all of the true lengths are obtained.

Before laying out the pattern for the transition piece, the opening in the funnel or cone is first developed as follows: Extend C F of the cone until it intersects the center line A B at N. Then using N as center and radii equal to N C, N 1′, N 3′, N 4′ and N F, draw arcs as shown. At pleasure draw any radial line as B^1 G^1 N. Now measuring from the line B G in plan, step off along the arcs to points 1 6 and 5, and place these distances along similar arcs in the pattern Y, measuring in each instance from the line B^1 G^1, thus obtaining the points 5 6 and 1 in the pattern.

Again measuring from the line B G in plan, step off along the various arcs to points 2, 3, 4 and 7 and place them in Y, stepping off on similar numbered arcs, measuring in each instance from the line B^1 G^1, and obtaining points 2, 3, 4 and 7. Trace a line through points thus obtained, shown shaded, which will be the opening to be cut into the cone pattern, and also furnishes part of the measurements used when developing the transition pattern.

For the pattern for the transition piece proceed as follows: Draw any line *a* 1 in W equal to *a* 1 in plan. With *a* 2 in plan as radius, and *a* in W as center, draw the arc 2, which intersect by an arc struck from 1 as center and 1 2 in plan as radius. Using G 1 or G 2 in plan as radius and 1 and 2 in W as centers, draw arcs intersecting each other in *n*, which use as a center, and with similar radius, describe the arc 1 2.

Thus it will be seen that 1 2 *a* in W is simply a reproduction of 1 2 *a* in plan, because 1 2 *a* lies in the same horizontal plane in elevation, and that the curve 1 2 in W will equal the curve 1 2 in Y. With *a h* in the circle in elevation as radius, and *a* in W as center, draw the arc *h*, which intersect by an arc, struck from 2 as center, with radius equal to 2 *h* in X as radius. Again using *h g* in the

circle in elevation as radius, and *h* in W as center, describe the arc *g*, which intersect by an arc, struck from 2 as center and 2 *g* in X as radius. Now with 2 3 in the opening in cone Y as radius, and 2 in W as center, draw the arc 3, which intersect by an arc struck from *g* as center and *g* 3 in X as radius. Again using 3 4 in Y as radius and 3 in W as center, describe the arc 4, which intersect by an arc struck from *g* as center and *g* 4 in X as radius.

Proceed in this manner, using alternately, first the divisions in the circle in elevation, then the true lengths in X. The divisions in the pattern for opening in Y, then again the proper true length in X, until the last line, *a′* 1′ in W has been obtained, similar to *a* 1. Thus the divisions in the pattern for the transition piece, which are numbered, are obtained from the spaces in Y; while the divisions in W, which are lettered, are obtained from the spaces in the circle in elevation, while the true lengths in W are obtained from similar numbered and lettered lengths in X.

A line traced through points of intersections thus obtained in W, will be the pattern for the transition piece, joining the opening in cone Y.

INTERSECTION OF HOPPER AND A PIECED ELBOW

This problem is: Given a flaring article, the base of which is elliptical and the top round, intersecting a pieced elbow. Required to find the line of intersection and the patterns, the dimensions are: A three-pieced elbow 36 inches in diameter, the throat of which was struck by an 18-inch radius, while the lower side of the elbow is intersected by a hopper, the top of which is an ellipse 24×42 inches and the base a circle 22 inches in diameter. The hight of the hopper is to be 30 inches, measuring from the lowest point of the elbow. In this case the hopper is seen to cross one miter line of the elbow. Whether the number of miter lines crossed be more than that shown, the principles governing the developments remain the same.

First draw the plan of the three-pieced elbow in the usual manner, as shown in Fig. 18 by A B C D E F G H. At right angles to B C construct a part elevation of the elbow, as shown by P R R′ P′, letting P R represent the top line of the elbow. In the required position in the plan draw the elliptical base of the hopper, 1 3 5 7, which represents a true section on the plane P R in elevation. Also, in the plan draw the circle 1′ 3′ 5′ 7′, which represents the circular base, or end, of the hopper on a plane parallel to P R in elevation. As 1 1′ in plan lies at right angles to B C, extend the line 1 1′ into the elevation,

and measuring from the line P R, make T X the required hight of the hopper, and from X draw a line parallel to P R. Through the center of the plan of the elbow draw the dotted line I J, which represents the highest point in the rounded surface of the elbow. Tangent to the ellipse and circle draw the line 6 6′, extending it until it intersects 1 1′ at *b*. Divide the ellipse from 1 to 6 into any desired number of spaces, as shown by 2, 3, 4 and 5, from which points draw lines to the apex *b*, intersecting the opposite half of the ellipse at 7, 8, 9 and 10 and the circle at 1′, 2′, 3′, 4′, 5′, 6′, 7′, 8′, 9′ and 10′. Then will these lines represent the planes of the various sections, which will be constructed to determine how far in each the hopper will be extended beyond the elliptical base before cutting into the elbow, all of which is necessary before any pattern can be developed. Now, from the various points 1 to 10 on the ellipse in plan erect lines at right angles to B C into the elevation, intersecting the line P R, respectively, from 1 to 10. In similar manner from the various points of intersections 1′ to 10′ in the circle in plan erect lines at right angles to B C, intersecting the line X 5′ in elevation, as shown from 1′ to 10′.

Parallel to E D in plan draw the line L M, and with K on the center line I J extended, as center, describe the part section of the elbow, as shown by N, *a*′, O, being careful to have *a*′ of the circle tangent to L M. The line L M will therefore correspond with P R of the elevation, both lines representing the plane of the elliptical base in their respective views. Now, to obtain the sections on the various planes indicated in plan proceed as follows: Extend the line 1′ 1 in plan until it intersects the center line I J of the elbow at *a*. From the intersections *a* and 1 draw lines parallel to B C, until they intersect the miter line F C, from which drop vertical lines on to the section N O, as shown by *a*′ and 1″. Now, take the spaces between points *a*, 1 and 1′ in plan and set them off on a horizontal line in the diagram S, as shown by *a* 1 1′. From 1′ erect the perpendicular 1′ X, equal to the hight T X in elevation. From 1 in S draw the perpendicular line 1 1″, equal to the distance measured from the line L M to 1″ in section. As the plane *a* 1′ in plan lies at right angles to B C, draw from *a* in S the perpendicular *a* K, equal to the radius K *m*′ in section. Then using K as center and K *a* as radius, describe the arc *a* *b*, which will pass through 1″, as shown. Now, draw a line from X through 1 until it intersects the curve *a* *b* at 1°. As the line *a* 1′ in S is tangent to the highest point of the elbow, corresponding with P R of the elevation, the plane of the ellipse, then will the distance from 1 to 1° show the amount that the line 1′ 1 in plan and elevation must be extended to meet the surface of the elbow in that section. To obtain this point of inter-

section in plan take the horizontal distance between points 1 and 1° in S and set it off from 1 on the line 1′ 1 in plan, thus obtaining the point 1°. To obtain this point in elevation take the vertical distance between the points 1 and 1° in S, and measuring from and perpendicular to the line P R in elevation, set it off on the line 1′ 1 extended, thus obtaining the point of intersection 1°.

Since the method of constructing the sections on the several plane lines before mentioned is exactly the same in each case (the difference in result being due entirely to difference in the relative positions of the several points) it will not be necessary to describe each in detail. The method of obtaining the section on the line 2 10′ of the plan is clearly shown at V, at the left in Fig. 18, while that on the line 3 9′ is shown above at U, and need not be described inasmuch as a full description of the method of obtaining the section on the line 4 8′ is considered necessary. The reason for this is that the line 4 8′ crosses the miter line F C of the pieced elbow, and in that respect possesses a feature not a part of the sections previously obtained. The section on this line should be first completed as though no miter line existed and it was intersecting the piece B C F G extended.

Therefore extend the plane 8′ 4 until it cuts G F extended at *o*, and also the bottom line E D of the elbow at *h*, and from *i* extend a line parallel to G F, intersecting 8 *o* at *j*′. The point *i* was assumed at convenience in developing the section 3 9′ simply to get an additional point in the curve *a c b* of the section U, and shown at *i*′. It is used again in this section for a similar reason. From the several points on *o* 8 in plan draw lines parallel to G F until they cut the miter line F C, from which intersections drop vertical lines, cutting the section N O at *m*′, *i*′, *e*′, *d*′, 4‴ and 8″. Set off the divisions on *o* 8′ on the horizontal line in W, as shown by *o*, *j*, 4, *e*, *d*, 4′, 8 and 8′. From the points 4′ and 8′ erect the vertical lines 4′ X and 8′ X equal in hight to T X in elevation. From the points *o*, *j*, *e*, *d*, 4′, 8 drop vertical lines making *o m*′, *j*, *i*′ *e e*′, 4′ 4‴, and 8 8″, equal respectively to similar distances measured from the line L M to points *m*′, *i*, *e*, 4‴ and 8″ in section N O. As *d* in plan represents the highest point, then *d* in W is in correct position in the section. Through the points *m*′, *i*′, *e*′ *d*′ 4‴, 8″ draw the curved line *m*′ *b*, and draw lines X 4 and X 8 intersecting the arc *m*′ *b* at 4^x and 8°, respectively. Now take the horizontal distance between the points 4 and 4^x and set it off on the proper plane line in plan, measuring from the point 4, thus locating the point 4^x. Draw a curved line in plan from 2 through 3° and 4^x, which will cross the miter line F C at A°. From A° drop a line into the section N O, intersecting it at A^x. From A° in plan, at right angles to B C, erect a line into the elevation intersecting R P at A, and from A set off the distance A A° equal

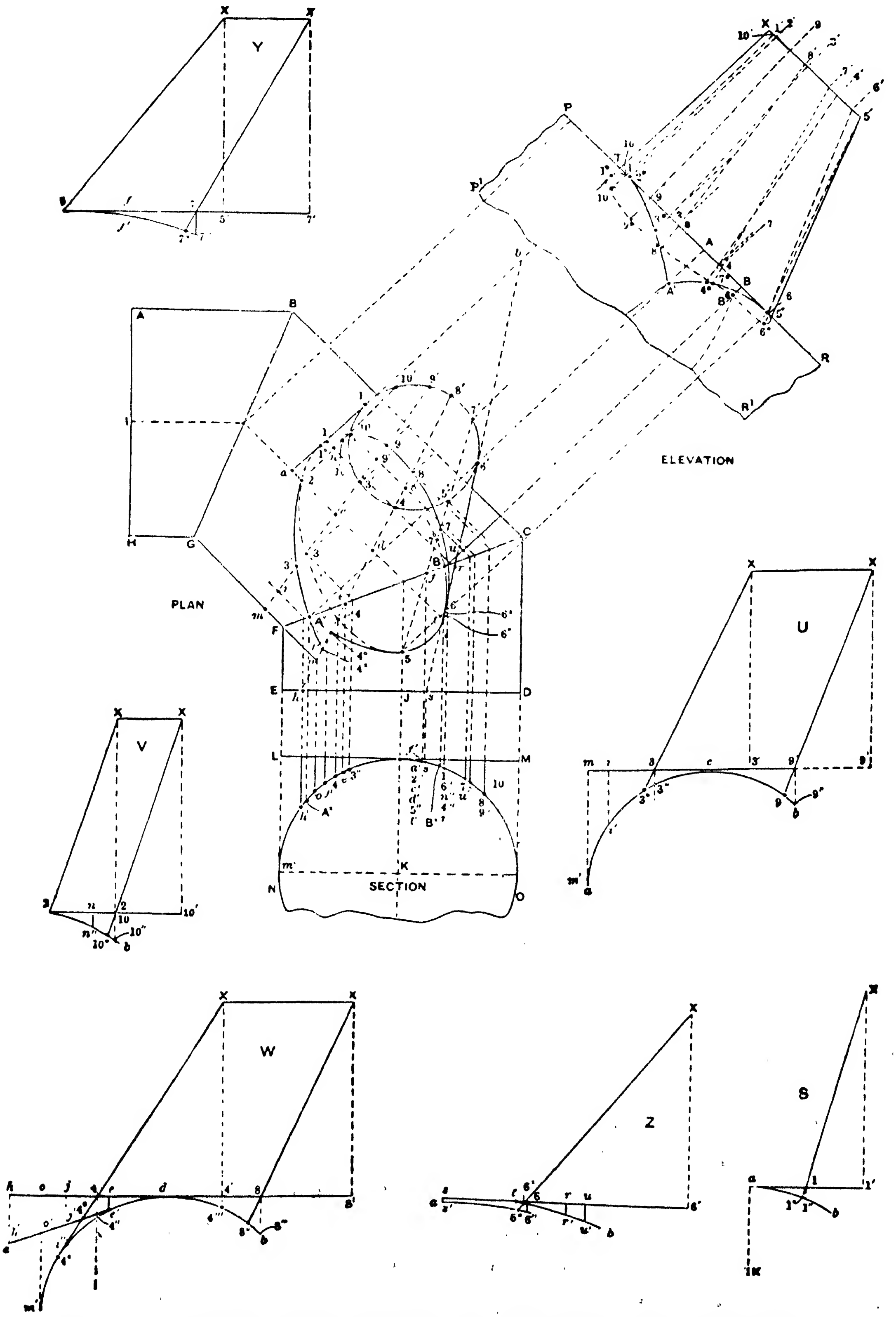


Fig. 18. Plan, Elevation and Developed Sections of Flaring Hopper Joining a Pieced Elbow

to the distance from A^x to the line L M in the section N O. Then will A° in elevation represent the position of the point A° of the plan. The next step is to find the intersection of the plane 8′ 4 with the portion of the elbow shown by F E D C. Therefore, in addition to the spaces on the horizontal line in W, set off from *o* the distance *o h* in plan, as shown. From *o*, *h* and 4 drop vertical lines, as shown, making *h h′*, *o o′*, *j j′* and 4 4″ equal to distances measured from L M in section to points *h′*, *o′*, *j′* and 4″ in N O. Through the points *h′*, *o′*, *j′* and 4″ draw the curve *a d*, which will intersect the line X 4^x at 4°. To obtain in plan the position of points 4° and 8° take the horizontal distances between the points 4 4° and 8 8° in W and set them off in plan on the line 8′ *h*, measuring respectively from the points 4 and 8, thus locating the points 4° and 8°. For their positions in elevation take the vertical distances in W, between the points 4 and 4° and 8 and 8°, and set them off respectively on the lines 4′ 4 and 8′ 8 extended in elevation, measuring perpendicularly from the line P R, thus locating the points 4° and 8°.

For the section on the plane 7′ 5 in plan, proceed as follows: From the point 7, parallel to B C, draw a line intersecting the miter line F C, from which point, including the points 5 and *f*, drop vertical lines intersecting the section N O at 7″, *f′* and 5. Now take distances between the points 5, *f*, 7, 5′ and 7′ in plan and set them off on the horizontal line in Y, as shown by 5, *f*, 7, 5′ and 7′. From the points 5′ and 7′ erect the perpendiculars 5′ X and 7′ X, equal to T X in elevation, and from the points *f* and 7 in Y drop vertical lines, making *f f′* and 7 7″, equal to the distances measured from the line L M to points *f′* and 7″ in the section N O. Through the points 5, *f′* and 7′ draw the arc shown. Draw X 5 and X 7, extending X 7 to intersect the arc 7°. Then will 5 X X 7° be the required section on the line 5 7′ of the plan. As point 5 is at the highest point of the curve in the plan its position in the elevation will be on the line P R in elevation, its position thereon being obtained by erecting from 5 in plan a line at right angles to B C. Now take the horizontal distance between the points 7 and 7° in Y and set it off on the line 7′ 5 in plan measuring from the point 7, thus locating the point 7°. In similar manner take the vertical distance between the points 7 and 7° in Y and set it off in elevation on the line 7′ 7 extended, measuring from and at right angles to the line P R, as shown by 7°.

As the plane 6′ 6 in the plan crosses the miter line F C, it will again be necessary to find at what point between 6 and 7 the line of intersection between the hopper and the pipe will cross the miter line F C. This point is shown by B°, and is obtained as follows: First consider this plane as intersecting the continua-

tion of the middle piece of the elbow B C. Extend the center line of the elbow, also the lines drawn through 4′ and 7, parallel to B C, until they intersect the plane line 6′ 6 at points *t*, *r* and *u*, and from their intersections with F C drop lines to N O as before. Take the various divisions *t*, 6, *r*, *u* and 6′ in plan and set them off, as shown by *t*, 6, *r*, *u* and 6′ on the horizontal line in Z. From that point 6′ erect the line 6′ X, equal in hight to T X in elevation. From the points *r* and *u* in Z drop vertical lines, making *r r*′ and *u u*′, equal respectively to similar distances measured from the line L M to points *r*′ and *u*′ in the section N O. As *t* in plan represents the highest point of the elbow, then will *t* in Z be the correct position in the section. Through the points *t*, *r*′ *u*′ draw the curved line *t b*, and draw a line from X through 6, intersecting the arc *t b* at 6^x. Take the horizontal distance between the points 6 and 6^x, and set it off in plan on the line 6′ 6, measuring from the point 6, thus locating the point 6^x, as shown. Draw a curve line through 7° and 6^x, which will cross the miter line F C at B°, the point desired. The full curve begins at point 1° and passes through 10°, 9°, 8°, etc., to 6^x. From B° drop a line into the section N O, intersecting it at B^x. From B° in the plan, at right angles to B C erect a line into the elevation, intersecting R P at B, then from B set off the distance B B°, equal to the distance measured from the line L M to B^x in N O. Then will B° in elevation represent the position of the point B° on the miter line. The next step is to find the intersection of the plane 6′ 6 in plan with that part of the elbow shown by F E D C. Therefore extend the line 6′ 6 in the plan until it intersects E D at *s*. From *s* drop a vertical line into the section intersecting N O at *s*. Set off the distance *t s* in plan on 6′ *t*, extended as shown at *s* in Z. From *s* and 6 drop vertical lines, making *s s*′ and 6 6″, equal to distances measured from the line L M to points *s* and 6″ in the section N O. Through the points *s*′ and 6″ in Z draw the curve *a c*, which will intersect the line X 6, extended at 6° To obtain this point in plan take the horizontal distance between the points 6 and 6° and set it off in plan on the line 6′ 6, measuring from the point 6, as shown. For the same point in elevation, take the vertical distance between the points 6 and 6° in Z and set it off on the line 6′ 6 extended, measuring from and perpendicular to the line P R in elevation, thus locating the point 6° in the view. The full curve in the plan above referred to may then be extended through 6° to 5 and on through 4° to A°. That portion of it lying beyond the hopper is shown dotted. This line is also similarly traced in the elevation, as shown. Then will this line represent the intersection of the hopper with the elbows in plan, and the true distances between the points, to be subsequently obtained, will form the bases of the triangles, which

must be constructed in developing the pattern of the hopper by the usual operations of triangulation. It is evident that these distances cannot be measured on the plan, because of the curved section of the pieces composing the elbows. The simplest method of obtaining the correct distances between the several points in the line of intersection is by developing the patterns for the several portions of the

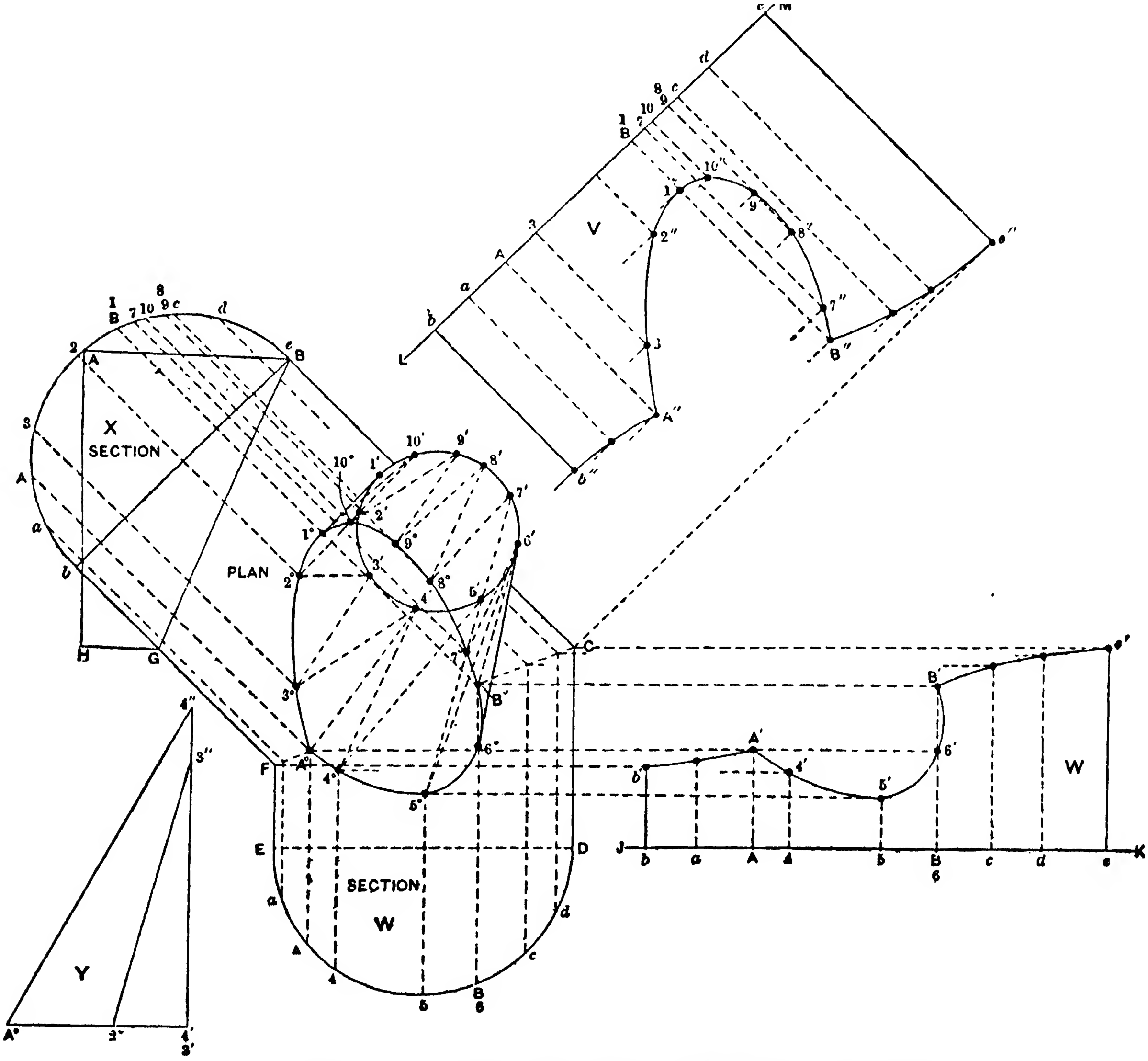


Fig. 19. Development of the Elbow Where Intersected by the Hopper

elbow. For this purpose Fig. 19 is therefore presented, in which A B C D E F G H and the various points of intersection 1°, 2°, 3°, A°, 4°, 5°, 6°, B°, 7°, 8° 9° and 10°, also the points of intersections on the circle 1′ to 10′, are reproductions of parts bearing similar letters and figures in Fig. 18. For the pattern for one-half of the lower piece of the elbow proceed as follows: Draw its half section

W on the line E D, as shown by E 5 D, and from the various points of intersections A°, 4°, 5°, 6° and B° drop lines intersecting W, as shown. Establish at pleasure the points *a*, *d* and c, and from them erect lines cutting the miter line F C, as shown. Extend E D, as shown, by J K, upon which place the stretchout of W, using the spaces contained therein, as shown, and from the several points erect lines at right angles to J K, which intersect by lines drawn at right angles to C D from points of similar number in plan. Trace a line through points thus obtained, then will *b* *b*′ A′ 5′ B′ *e*′ *e* be the pattern for the half of the lower part of the elbow, to intersect with a portion of the hopper. Thus the various distances between point A′, 4′, 5′, 6′ and B′ are the true distances between similarly numbered points in plan. For the pattern for the center part of the elbow, draw the half section X in line with the center part, as shown, and from the various points on the miter line F C and the points 7°, 8°, 9°, 10°, 1°, 2° and 3° draw lines parallel to B C, intersecting the half section X, as shown. At right angles to B C draw any line, as L M, upon which place the stretchout of all of the spaces contained in the half section X, as shown by similar letters and figures, and through the points thus obtained draw lines at right angles to L M, which intersect with lines drawn at right angles to B C from points of similar number in plan. Trace a line through points thus obtained, as shown by *b*″, A″, 10″, B″ and *e*″, which will represent the miter cut to join the lower piece and also the opening to be cut into same to admit the remaining portion of the hopper. Thus the various distances between the points A″, 3″, 2″, 1″, 10″, 9″, 8″, 7″ and B″ are the true distances between similar numbered points in plan.

The method of triangulating the body of the hopper is shown by the dotted lines connecting points of similar number in the two bases and the dotted lines drawn between. The altitudes of the triangles must be obtained from the elevation in Fig. 18, as shown in the diagram Y of Fig. 19, showing one pair of triangles, which may be identified by the reference letters and figures. With the several points in the elliptical base of the hopper determined, those of the circular base given and the method of obtaining the hypotenuses of the triangles indicated, those who are familar with the usual operations of triangulation will find no difficulty in developing the pattern.

PATTERNS FOR BRANCH INTERSECTING SIDE OF ELBOW

A problem was submitted involving a connection, as shown in Fig. 20, in which A B in the end view represents a branch pipe intersecting the side of a

five-pieced elbow, as shown in the side view by C, the branch having the same diameter as the elbow.

In this connection it may be proper to say that the miter line *a b c* in the end view in sketch does not represent the true line of intersection between the branch and elbow; and as this intersecting line is not necessary in the development of the patterns, the method of projecting this miter line will be omitted in the drawings, which are given in Fig. 21, as all that is required is the side elevation of the elbow.

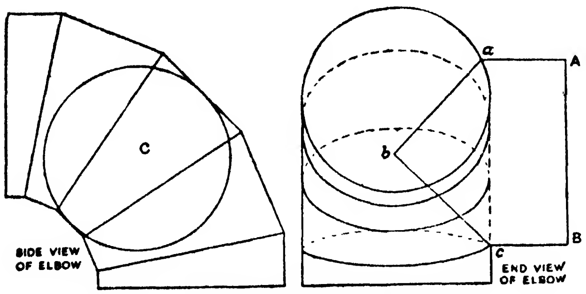


Fig. 20. Sketch of Submitted Problem

Let C D E F represent the side elevation of the five-pieced elbow, and A the section of the elbow on the line E F. Divide A into any convenient number of spaces, in this case from 1 to 7 to 1. Through these points erect vertical lines until they intersect the first miter line as shown. From these intersections, parallel to the sides of the lower piece S, draw lines to the second miter line, from which points, parallel to the sides of piece B, lines are drawn to the third miter line and continued in this manner until the line C D has been intersected.

As the branch is to come directly over the middle piece of the elbow, draw a center line through the middle piece B as shown by 1 7, and where it crosses the center line 4 4 at X becomes the center point with which to strike the profile of the branch B. This profile will intersect the various lines at points numbered 1 to 7 on both sides as shown. Where the profile B crosses the miter line at *a*, establish another line in elevation as well as in plan as shown in both views by the letter *a*.

Establish at pleasure the length of the branch 1 H and 7 J. Extend H J as H K and obtain the pattern for the branch as follows: Take the stretchout of the profile of the branch B in elevation from 1 to 7 to 1, including the point *a*, being careful to measure each space separately, as they are all unequal, and place it as shown by similar letters and figures on J K. From these points erect perpendiculars to J K and intersect them by horizontal lines drawn parallel to H K from similar numbered and lettered intersections on the lower half of the profile A. Trace a line through points thus obtained, then will 1 *c d e* 1 be the full pattern for the branch B, with seam at 1 in side elevation.

As the branch comes directly in the center of the three pieces of the elbow, then the pattern for the lower piece S will also answer for the upper piece S. At

right angles to the side of the lower piece S draw the line N P, upon which place the girth of the profile A, including the point *a* between 5 and 6, as shown by similar numbers on N P. Through these points, at right angles to N P, draw perpendiculars, which intersect by lines drawn parallel to N P from the various intersections on the miter line T R at the bottom and U 2 *a* V at the top. A line traced through points thus obtained, as shown by *m, n, o, r, s, t, u,* will be the pattern for the pieces marked S in elevation.

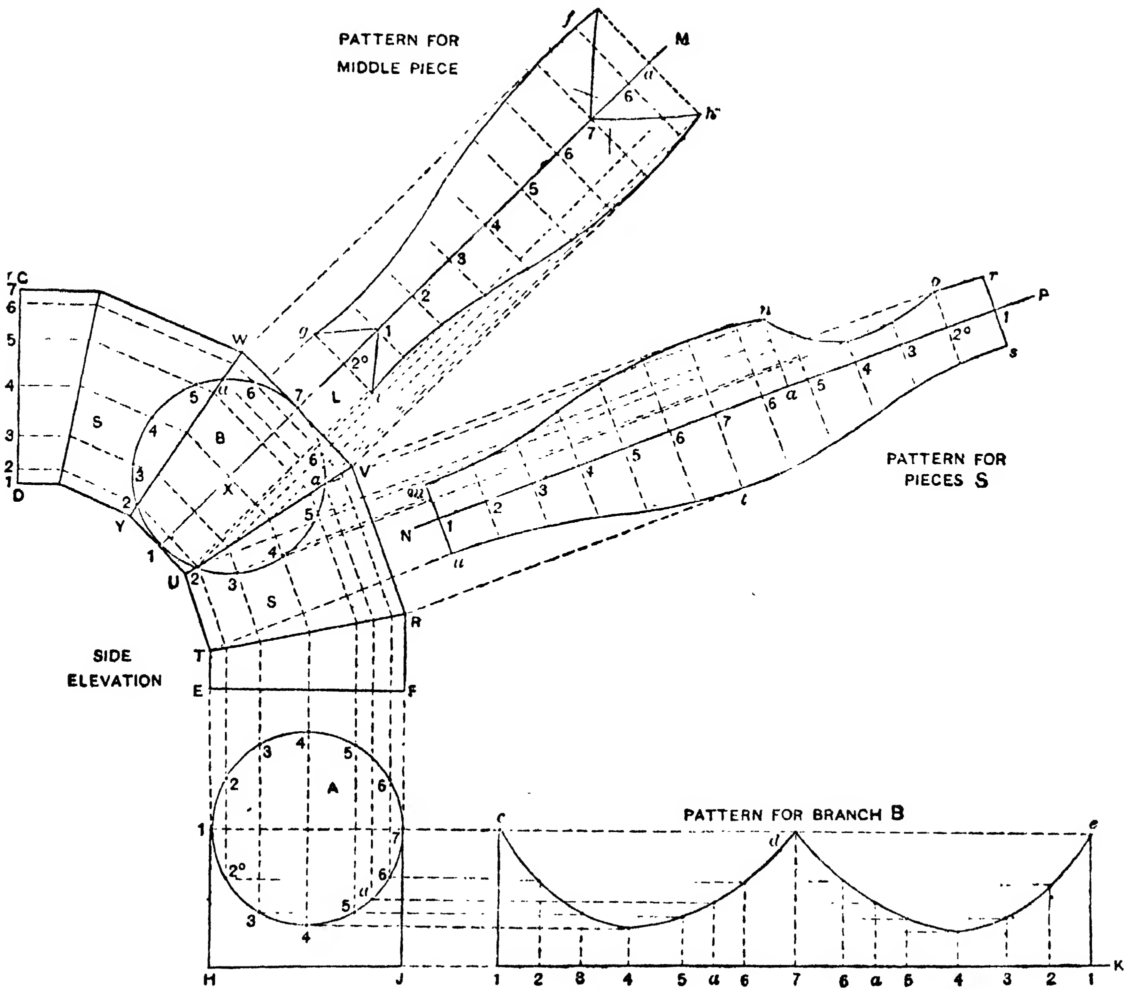


Fig. 21. Elevation, Sections and Patterns for Branch Intersecting Side of Elbow

For the pattern for the middle piece it will only be necessary to take the girth from 2° to 1 to 7 to *a* in the profile A and place it on the line L M, drawn at right angles to the middle piece of the elbow in elevation. Through the various points on L M draw perpendiculars which intersect by lines drawn parallel to L M from the various intersections on the miter lines 2 U V *a* and 2 Y W *a*. A line traced through points thus obtained, as shown by 1, *g, f,* 7, *h, i,* will be the

pattern for the middle piece. Laps must be allowed on the elbow pieces for seaming and on the branch for riveting.

PATTERNS FOR ELBOW MITERING AGAINST SOFFIT OF WINDING CHUTE

The following is a method of developing the patterns for an elbow mitering against the soffit of a winding chute. The drawings show a plan and elevation representing each of the four sides of the article in question, a portion of which are reproduced in Fig. 22 of the accompanying diagrams, while Fig. 23 is a perspective of the article in question. The rear and one of the side elevations are omitted in Fig. 22, for the reason that they show nothing not given in the other views. The elevations being projected from the plan necessarily have their tops turned toward the same, but as the side view is in this case the one most useful in obtaining the patterns, the drawings are turned on the page so that this view occupies an erect position.

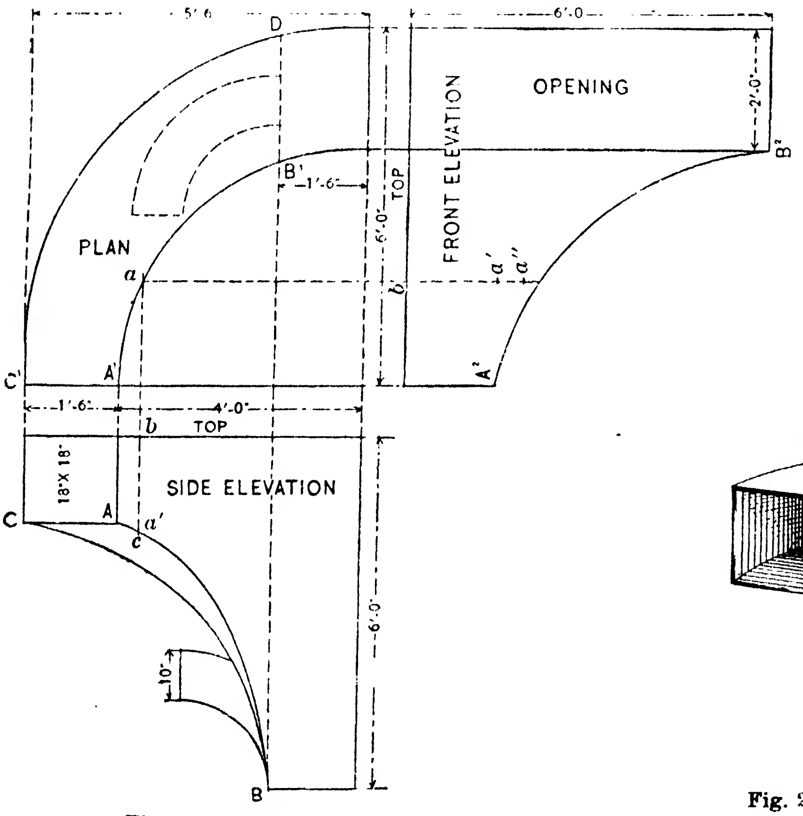


Fig. 22. Sketch to Give an Idea of Problem

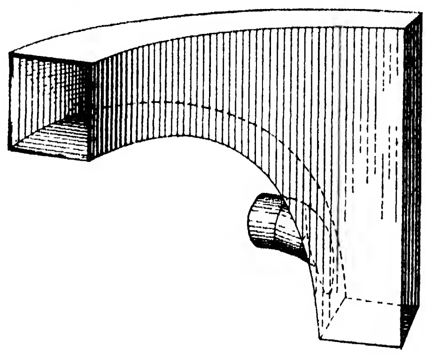


Fig. 23. Perspective View of Article Shown in Fig. 22

The drawing of Fig. 22 is not correct and as the operation of projecting correctly the several elevations from the plan and one given elevation is of prime

importance in the solution of many problems, the method by which the several elevations may be made to correspond in every particular is briefly given. If the curve A B of the side elevation in Fig. 22 is accepted as correct, it must first be divided into convenient spaces and lines from the several points of divisions dropped vertically upon the corresponding line A^1 B^1 of the plan. If a front elevation is desired, lines must now be carried from the several points on A^1 B^1 toward the front of the plan indefinitely—that is, at right angles to the first set of lines drawn—upon which the hights of the several points on A B must be set off from any horizontal line, as the line of the top. A line traced through the points thus obtained in the front elevation will then exactly correspond with A B of the side elevation. The line obtained by the foregoing process from A B would be very much different from the line A^2 B^2 already drawn in front elevation, as will presently be shown.

While only one view, when corrected, is necessary in obtaining the pattern, the above operation will greatly assist in completing the design, from the fact that neither elevation will in the present case present such outlines as will be apparent to the eye in the finished article. For instance, if any point, as a, be assumed upon the inner curve of the plan somewhere near the 18 × 18 inch opening and lines be projected therefrom in both the elevations, as shown dotted in Fig. 22, it will be discovered that the intersection with A B of the side elevation at a' is much nearer the top line or point b than is the intersection a'' of the front elevation as drawn, the difference being there shown by a' a''. This is because the sides of that portion of the chute near the 18-inch opening are very oblique to the plane of the side view, and therefore do not present the outlines of the soffit as they really are; in other words, the point a' is much further back of A than it appears, while those portions of the curve nearer the larger 6-foot opening are more correctly shown in the side view, and for the same reason would, if correctly drawn, be correspondingly distorted in the front view. It then becomes apparent that the outline in one or the other, or perhaps in both views, is wrong, and that as a matter either of design or of utility, as the case may be, the view from which the patterns are to be obtained, in this case the side view, should be so corrected as to produce the desired result. That is, if a line drawn through points A^2 and a' of the front elevation (not shown) be considered as having the proper pitch or slant, then the line from A to B, passing through a' of side elevation, may be assumed as correct; but if such pitch, when shown in the front view, be not deemed sufficient, then a point somewhere below a' of the elevations, as c or a'', must be assumed and the curve A B so drawn as to pass through it.

To assist the reader in forming a correct idea of the figure under consideration Fig. 23 shows a perspective view of the same as it would appear if made approximately from the plan and side elevation shown in Fig. 22, from which the inclination of the soffit at all parts of its course may be seen.

Before the operations of the pattern development can be begun one other matter must be determined—viz., the exact nature of the soffit or curved surface forming the bottom (and in its lower part the back) of the chute. This surface, as shown in plan by A^1 B^1 D C^1 and in the side elevation by A B C, is similar to the soffit of an arch in a circular wall.

In the treatment of this surface, in view of subsequent operations, the pattern cutter, as in many other instances, is called upon to choose between the method which adheres strictly to the drawings as given him, and thereby leads him into intricate complications, and a course which is very much simpler and more practicable, though not following out the design to the letter. Since it is against this surface that the elbow, partially outlined in Fig. 22, is required to miter, and since the pattern for such a surface can only be developed by triangulation, it will be seen that the several triangles into which its surface is divided by the operation of obtaining its patterns are all small planes, each slanting at a different angle, and that to obtain with accuracy the intersections of the different pieces of the elbow with the several triangular planes which may lie in the path or course of each would involve much labor. There is no limit to the intersections which it is possible to obtain if necessary, so long as the surfaces or figures involved and their relative positions can be geometrically defined. Such operations would no doubt be more interesting and instructive than practicable. In view, then, of the above mentioned conditions, so far as obtaining the patterns is concerned, the intersection of the elbow can be greatly simplified by considering the soffit as a portion of a somewhat cylindrical surface, having a profile A B of the side view, Fig. 22, thus doing away with the line C B. At all events, if a single line be used from B to a point above where the 10-inch elbow enters, the further outline may then be allowed to deviate to the point C, as shown in Fig. 25, if it is desirable to adhere to the original character of the design as given in the side view of Fig. 22. This arrangement reduces the intersection of the elbow with the curved soffit, shown in detail in Fig. 26, to a problem in miter cutting so simple as to scarcely require demonstration; and if, as above mentioned, the single line A B be adopted as the profile of the soffit, the same may be said of the remainder of the work.

The method of obtaining the pattern of the soffit upon this supposition is shown upon the plan of Fig. 24. Since that portion of the pattern corresponding to C A of the profile, which is horizontal, must be the same as shown in the plan, the remaining portion of the profile A B is divided into any convenient number of equal spaces, as shown by the figures 1 to 7 at the right, and a stretchout of the same, beginning at A^1, is set off on C^1 A^1 of the plan, extended as shown by A^1 E. Lines from the several points on A B are then carried upward to intersect with the

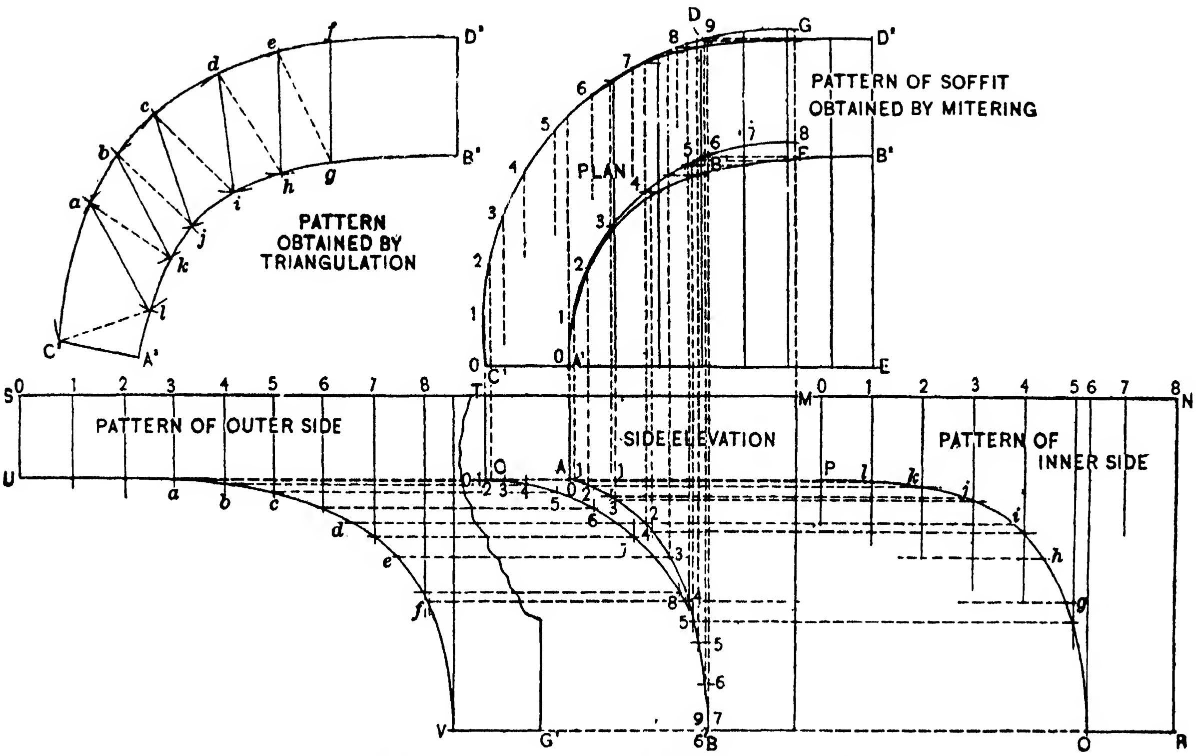


Fig. 24. Process for Obtaining Patterns of Chute

outlines of the sides A^1 B^1 and C^1 D of the plan, from which points of intersection lines are carried into the measuring lines of corresponding number of the stretchout in the usual manner. Then will A^1 B^2 D^8 C^1 be the pattern of a soffit of which C A B is the profile. That portion of the pattern corresponding to C A of the profile, being horizontal, is obviously the same as C^1 A^1 *c* of the plan itself, to which the remaining portion corresponding to A B of the profile, is added, as above described. The intersections are not numbered on the sides of the plan to avoid confusion with another set of numbers on each, which will be used in obtaining the patterns of the sides.

If, however, it is desirable, as before described, to adopt the line C B as drawn in Fig. 25 as the further outline of the soffit, the pattern must be obtained by tri-

angulation. As its sides must correspond in length, respectively, with the lower edges of the two side pieces of the chute, it will be most convenient to develop the patterns for the side pieces first.

Therefore divide A^1 F of Fig. 24, the plan of the inner side, into any convenient number of equal spaces, as shown by the small figures 1 to 8, and set off a stretchout of the same on the top line of the elevation, extended as shown by M N, and draw the usual measuring lines. From the several points on A^1 F drop lines, cutting the line A B of the side, as shown by the small figures on the left of A B, and from the several points of intersection carry lines horizontally, cutting measuring lines of corresponding numbers, and trace a line through the several intersections as shown by P Q R. Then will P Q R N M be the pattern for the inner side. It will be noted that a line from point B of the side must be projected onto the plan, where it is designated as 6. It must then be correspondingly located on M N, so as to determine the position of point Q of the pattern. The pattern for the outer side is obtained in exactly the same manner by dividing its profile or plan C^1 G into spaces, which are set off on the line S T for a stretchout. Lines from the points on C^1 G are then dropped into the line C B of the side view and are carried thence into the measuring lines, all as shown at the left in Fig. 24. The line C A B may be used instead of C B if the mitered pattern above obtained is to be used.

The triangulation of the soffit piece is shown in Fig. 25, but the pattern as obtained therefrom is shown in the upper part of Fig. 24 at the left. Since from the nature of the design there is no view in which the full length of its sides can be given, any method of dividing them into spaces may be adopted which is most convenient. The line A B of Fig. 25 is therefore first divided by the points *j*, *i*, *h* and *g* into equal spaces down to the point *g*, which corresponds with the point 4 of the first division of A B, Fig. 24, used in obtaining the first or mitered pattern of soffit, and which also represents the point of deviation between the line of the inner side B A of the soffit and that of the outer side B C. On account of the coincidence of the two lines from B up to this point it is evident that the two patterns must be alike for the same distance, therefore in beginning the triangulated pattern first transfer a duplicate of that portion of the mitered pattern from the measuring line 4 of the stretchout A^1 E of Fig. 24 to the end B^2 D^2 to any convenient position, as shown by *f g* B^3 D^3 at the left.

Now erect lines from points in A B of Fig. 25 to cut line A^1 B^2 of plan, after which it will appear that a very long space occurs from A^1 to point *j* of the

plan. This space may be further divided by points k and l, and lines from these points of division carried back to the side view and correspondingly lettered, as shown. From the several points g to l of the side view carry lines horizontally across, cutting the outer line C B at points a to f, and from these points erect lines, cutting the outer line of the plan C^1 D^1, as shown by corresponding letters. Connect points on the inner with those on the outer line of the plan with solid lines corresponding with those just drawn across the side view, as f g, e h, etc., and divide the spaces so obtained by means of dotted lines drawn through the shorter diagonal of each, as e g, d h, etc. In determining the true lengths of the sides of the several triangles into which the plan of the soffit has thus been divided it will be seen that the lengths of the solid lines and of the dotted line C^1 l may be taken directly from the plan as given, because they represent the horizontal lines

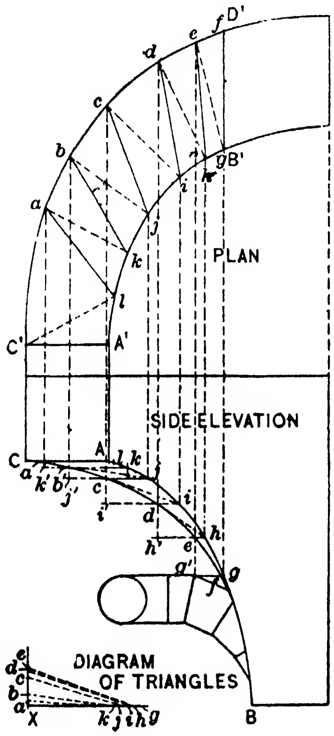


Fig. 25

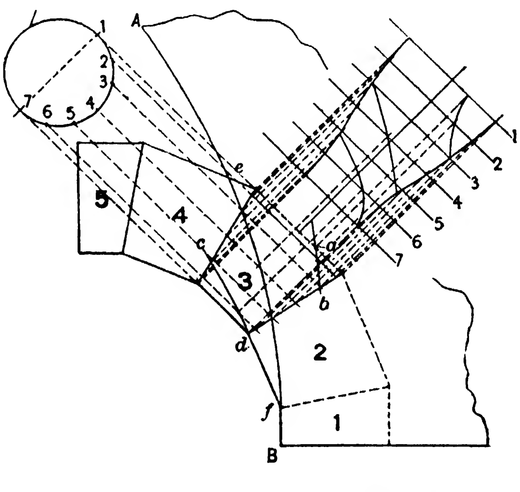


Fig. 26

Process for Obtaining Patterns of Elbow

of the side view, but that the true length of the dotted lines must be obtained by constructing a diagram of triangles, as shown below in Fig. 25. Therefore, from each of the various points g, h, i, etc., on the line A B draw a horizontal line to a point directly below the next higher point on the line C B, from which drop a perpendicular. Then will the several perpendiculars g' e, h' d etc., be the altitudes of the right angled triangles of the diagram, of which the dotted lines will be the bases.

In constructing the diagram of triangles the several hights X a, X b, X c, etc., are made equal to k' a, j' b, i c, etc., of the side elevation, while the bases X k, X j, X i are made equal to the dotted lines a k, b j, c i, etc., of the plan. The

several hypotenuses *a k*, *b j*, *c i*, etc., of the diagram will then be the true lengths of the dotted lines of corresponding letters in the plan.

In order to find the true lengths of the spaces *a b*, *b c*, etc., of the outer side and *l k*, *k i*, etc., of the inner side it will be necessary to find points exactly corresponding to them on the outlines or miters, U V and P Q of the patterns of the side pieces previously obtained in Fig. 24. Therefore from the points 1, 2, 3 and 4 as numbered on the right of A B of Fig. 24, which correspond exactly with points *j*, *i*, *h* and *g* of A B, Fig. 25, project lines in either direction, cutting the lines U V and P Q of the patterns, as shown, and lettered to correspond respectively with the points on C B and A B of Fig. 25. Then will the spaces *g h*, *h i*, etc., and *f e*, *e d*, etc., be the correct lengths of the spaces bearing corresponding letters of the plan, Fig. 25.

To complete the pattern as shown in the upper left hand corner of Fig. 24, of which the portion *g f* D^3 B^3 has already been obtained as described above, take first the distance *e f* of the pattern of side just below, and from *f* of pattern as center describe a small arc near *e*, which intersect with another arc the center of which is *g* of the pattern and the radius of which is *g e* of the diagram of triangles in Fig. 25, thus locating the point *e*. In the same manner, with radii respectively equal to the spaces *g n* of the pattern of the inner side and *e n* of the plan in Fig. 25, describe arcs intersecting at *h*. So continue, using the spaces upon the pattern of the outer side piece for distances on the outer side of the pattern and those from the pattern of inside piece for distances on inner side of pattern; also lengths from plan in Fig. 25, for distances on the solid lines across the pattern and lengths from the hypotenuses of the diagram of triangles for distances on the dotted lines of the pattern, all as shown. Having carefully followed the foregoing instructions, lines traced through the intersections of arcs, as shown by A^3 *g* and C^3 *f*, will complete the pattern. That portion of the curve from C^3 to *a* of the pattern may be transferred from the corresponding arc of the plan, since the surface of the soffit at that part is practically horizontal and therefore correctly shown in the plan, a fortunate saving of tedious triangulating.

The intersection of the elbow with the cylindrical surface at B *g* of Fig. 25 is shown somewhat enlarged in Fig. 26. The elbow, as if completed, is there drawn in five pieces, but any number of pieces desired can be used. As will be seen, piece 1 is entirely eliminated by the intersection, while pieces 2, 3 and 4 miter against the surface of the soffit. The operation of developing the pattern of piece 3 is first shown as though it were an entire piece. The intersections of the miter line A B with pieces 2 and 4 have been transferred to corresponding points on

piece 3, as shown at a b and c d, so that the operation of developing the patterns for the three pieces is performed at once, a half pattern of all the pieces being shown, from which the full pattern for each piece may be traced, making the joint either at the throat or at the back, as described. As should be readily understood, these operations can be performed while transferring the patterns to the sheet metal. The stretchout is obtained from a profile of the elbow placed in line with piece 3 of the elevation, and the subsequent operations are so fully shown in Fig. 26 as to require no further demonstration.

The length of the opening in A B to receive the elbow is equal to e f and its stretchout may be taken from the points of intersection on A B for piece 3, to which is added above that of a b for piece 4 and below that of c d for piece 2. The width of the opening at the several points is equal to that of the profile on lines of corresponding number. Naturally, said opening would be drawn in its correct position on the pattern for the soffit of the chute.

PATTERNS FOR INTERSECTION BETWEEN CYLINDER AND TRANSITION PIECE

The following deals with the method of obtaining the patterns for the intersection between a cylinder and transition piece, as is shown in Fig. 27. A B C D E F in Fig. 28 represents the front elevation, and G H I J the section in plan on the line F C in elevation and K L M N in plan the horizontal projection of the section on the line E D in elevation.

Through the center O in plan draw the two diameters G I and H J at right angles to each other. Draw the lines of transition N to J to M to I to L to H to K to G to N. From the front elevation construct one-half of the side elevation as follows: Draw the center line B^1 G^1, as shown, and take a tracing of the half plan G N M I O J and place it, as shown, opposite the center line B^1 G^1 by G^1 N^1 M^1 I^1 O^1 J^1, placing the line G^1 I^1 on the center line B^1 G^1, as shown. From the points F, D and E in front elevation project lines to the left. Extend the line N^1 M^1 in plan, intersecting the lines drawn from E and D at N^2 and M^2, respectively. From J^1 in plan parallel to the center line draw a line intersecting the line drawn from F at 6. Extend 6 A^1 and draw lines from 6 to M^2 to N^2 to 6. Then will A^1 B^1 E^1 N^2 M^2 6 A^1 be the one-half side elevation. The reader should

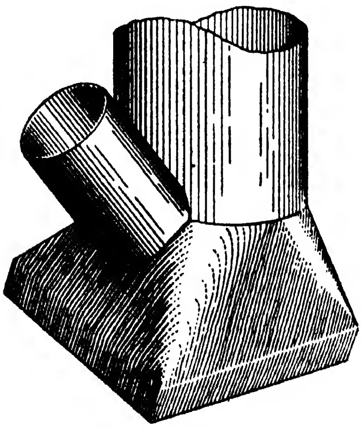


Fig. 27. Perspective View of Cylinders and Transition Piece

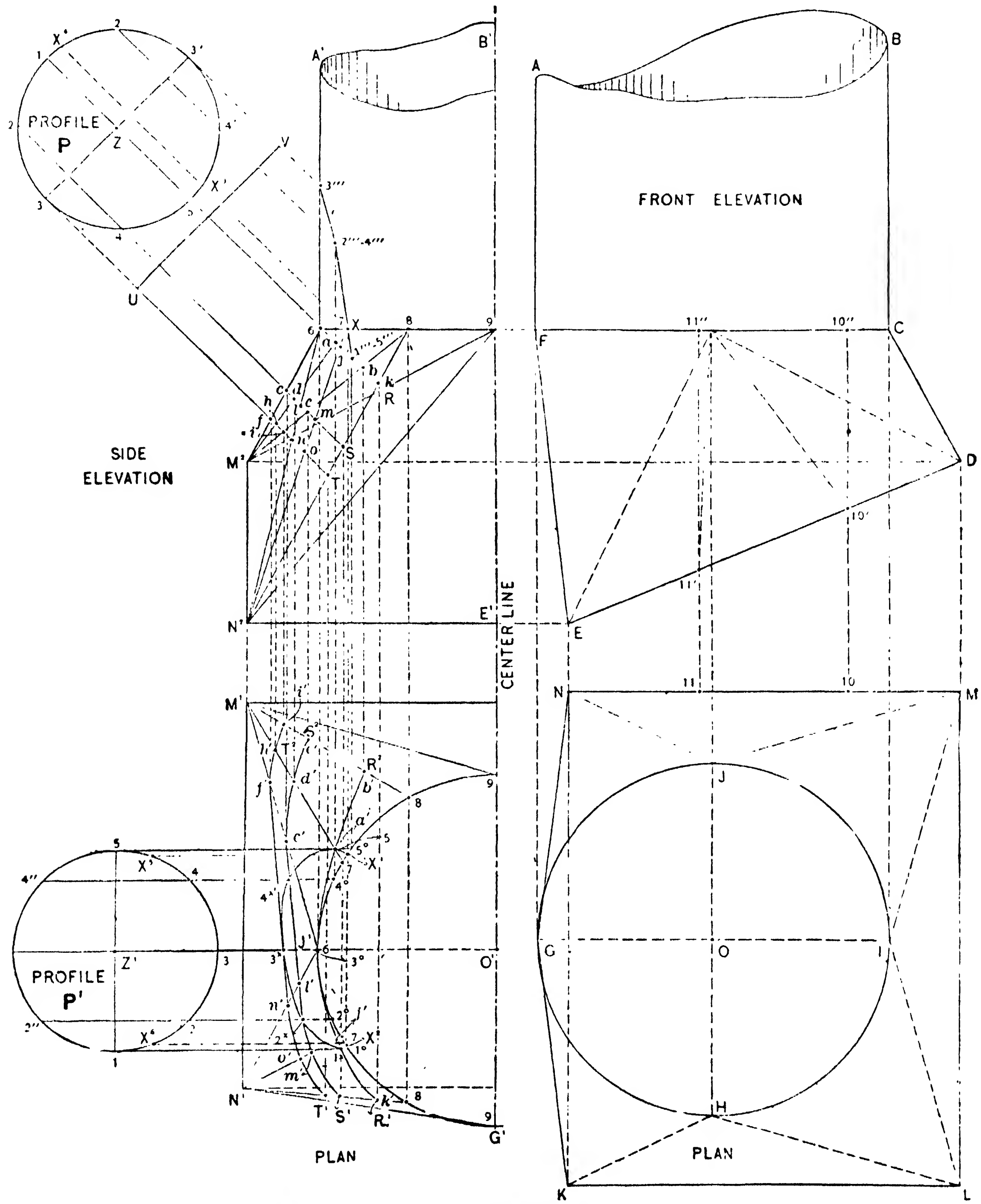


Fig. 28. Procedure for Obtaining the Miter Lines

understand that the point N^2 is the lowest point of the transition piece and is represented in plan by N^1, while M^2 in elevation is the highest point and is represented in plan by M^1.

The first step is to obtain the radial lines in both plan and elevation of the partial scalene cones. Divide the two quarter circles I^1 J^1 and J^1 G^1 in plan both into the same number of equal parts, as shown by the small figures 6, 7, 8 and 9 on both sides. From these points draw radial lines toward the apexes N^1 and M^1, respectively. Parallel to the center line B^1 G^1 and from 6, 7, 8 and 9 erect lines intersecting 6 9 in side elevation at 6, 7, 8 and 9. From these figures draw radial lines to the apex M^2, and from similar figures to the apex N^2.

From any desired point, as 6 in the side elevation, at its proper angle, draw the center line of the branch pipe, as shown by 6 1. With Z as center describe the profile P. Then through Z at right angles to 1 6 draw the diameter 3 3′. Divide the profile P into any number of equal parts, as shown by 1 2 3 4 5 4′ 3′ 2′. Parallel to 3 3′ draw at pleasure the line U V.

It will be noticed that the upper part of the pipe from X^3 to X^4, points which will be established later, intersects the vertical round pipe, while the lower part of the inclined pipe, X^3 3 X^4, intersects the transition piece. Before obtaining the intersection or miter line between part of the inclined pipe and the transition piece horizontal sections must be obtained in plan. Assume that the inclined pipe will not cut any deeper than to the radial lines 8 N^2 and 8 M^2 in side elevation. Then at right angles to U V and from the small figures in the profile P draw lines intersecting the radial lines 6, 7 and 8 in 6 9 M^2 and 6, 7 and 8 in 6 9 N^2, as shown by R, S and T. Thus the lines drawn from 1 5, 2 4 and 3 in the profile P intersect the radial lines in 6 M^2 8 at 6, *a*, *b*; *c*, *d*, *e*; and *f*, *h*, *i*, respectively, while similar lines intersect the radial lines in 6 N^2 8 at 6, *j*, *k*; *l*, *m*, S; and *n*, *o*, T, respectively.

From the intersections 6, *c*, *f* on the radial line 6 M^2 in side elevation drop lines intersecting the radial line 6 M^1 in plan at 6, *c′* and *f′*, respectively. Then from the intersections *a*, *d* and *h* on the radial line 7 M^2 in elevation drop lines intersecting the radial line 7 M^1 in plan at *a′* *d′*, and *h* . Finally from the intersections *b*, *e* and *i* on the radial line 8 M^2 in elevation drop lines intersecting the radial line 8 M^1 in plan at *b′*, *e′* and *i′*. From the intersections 6, *l* and *n* on the radial line 6 N^2 in elevation drop lines intersecting the radial line 6 N^1 in plan at 6, *l′* and *n′*. Then from the intersections *j*, *m* and *o* on the radial line 7 N^2 in elevation drop lines intersecting the radial line 7 N^1 in plan at *j′*, *m′* and *o′*. Finally from the intersections R, S and T on the radial line 8 N^2 in elevation drop lines intersecting the radial line 8 N^1 in plan at R^1, S^1 and T^1.

Now through the points of intersections i', h', f', n', o' and T^1 draw the section line T^1 T^2, which will represent the horizontal section on the line f T in elevation. In similar manner in plan through the intersections e', d', c' l', m' and S^1 draw the section line S^1 S^2, which will represent the horizontal section on the line c S in elevation. Finally, through the intersections in plan b', a', 6, j and k' draw the section line R^1 R^2, which represents the horizontal section on 6 R in elevation.

In the desired position in plan next draw the center line of the inclined pipe, as shown by J^1 3″. With any point as Z^1, as center, describe a duplicate of the profile P in elevation, as shown by P^1. Divide the profile P^1 into the same number of spaces as the profile P. As the points 3′ and 3 in the profile P represent the top and bottom of the inclined pipe respectively, then must the points 3 and 3″ in the profile P^1 be placed in the position shown, so that if the circle was turned on the line 1 5 the points 3 and 3″ will represent the top and bottom respectively of the inclined pipe in plan.

Parallel to 3″ 3 in plan and from the small figures in the profile P^1 draw lines intersecting similar section lines in plan, as follows: As the point 3 in the profile P in elevation cuts the section line T, then must the point 3 in the profile P^1 in plan intersect the section line T^1 T^2, as shown by 3^x. Then as the points 2 and 4 in the profile P in elevation intersect the section line S, then must the points 2 and 4 in the profile P^1 in plan intersect the section line S^1 S^2, as shown by 2^x and 4^x. Finally, as the points 1 and 5 in elevation intersect the section line R, then must the points 1 and 5 in the profile P^1 in plan intersect the section line R^1 R^2 in plan, as shown by 1^x and 5^x.

It will now be necessary to find the point of intersection between the inclined pipe in elevation and the joint line 6 9 of the transition piece. Therefore, at right angles to 1 5 in plan and from points 1, 2″, 3″, 4″ and 5 draw lines intersecting the semicircle 1^1 J^1 G^1 at 1°, 2°, 3°, 4° and 5°, respectively. From these intersections and parallel to the center line erect lines intersecting lines having similar numbers drawn from the points 1, 2′, 3′, 4′ and 5 in elevation in profile P at right angles to 3 3′, thus obtaining the intersections 3‴ 2‴, 4‴ and 1‴ 5‴. Trace a line through points thus obtained, as shown from 1‴ to 3‴, intersecting the joint line 6 9 at X. From X at right angles to U V draw a line intersecting the profile P at X^3 and X^4. Now, from X at right angles to 6 9 drop a line intersecting the half circle in plan at X^1 and X^2. From these two points at right angles to the center line draw lines intersecting the profile P^1 at N^5 and X^6, which will give the same location as similar points in the profile P. Through the points in plan X^1, 5^x, 4^x, 3^x, 2^x 1^x and X^2 draw the miter line.

The next step is to obtain the miter line in elevation between the inclined pipe and transition piece. To avoid a confusion of lines, which would otherwise occur, a tracing is made in Fig. 29 of the plan and elevation in Fig. 28. In Fig. 29, from the various points of intersections in the miter line in plan, X^1 3^x X^2, erect lines parallel to the center line, intersecting lines drawn from similar numbers in the profile P at right angles to U V, thus obtaining the points X, 1, 2, 3, 4 and 5 in elevation. Trace a line through points thus obtained; then will 3′ X 3 X 3′ be the miter line between the inclined pipe, the transition piece and the main pipe.

For the pattern for the inclined pipe proceed as follows: On the line V U extended, as U D, place the stretchout of the profile P, introducing the extra points X and X, as shown. At right angles to D U and from X and X and the small figures draw lines, which intersect with lines drawn from points having similar numbers in the miter line 3′ X 3 parallel to U V. A line traced through points thus obtained, shown by T L H F W K, will be the pattern for the cylinder branch, with the seam at V 3′ in elevation.

For the pattern for the opening, to be cut into the main pipe A B C X 3′ to receive part of the branch pipe, draw at right angles to the center line any line, as A^1 B^1, upon which place the stretchout of that portion of the plan in Fig. 28 which is intersected from points in the profile P^1, as shown by X^2 2° 3° 4° X^1. These are shown by similar figures on A^1 B^1 in Fig. 29. At right angles to A^1 B^1 and from the small figures draw lines, which intersect with lines drawn from points having similar figures in 3′ X in elevation at right angles to the center line. A line traced through these points, as shown by C^1 D^1 E^1, will be the required cut.

Only one-half of the pattern for the transition piece will be developed, as both halves are symmetrical, but diagrams of triangles must first be constructed as follows: In Fig. 30 draw any horizontal line, as & A, upon which place the various lengths M 9, M 8, M 7 and M 6 in plan in Fig. 29 as shown by & 9, & 8, 7 & and 6 & on & A in Fig 30. At right angles to & A erect & M, equal to & C in elevation in Fig. 29. Then from the points 6 9 and 7 8 draw lines to M in Fig. 30, which will represent the true lengths on similar lines in plan in Fig. 29.

In similar manner draw any horizontal line, as E A in Fig. 31, upon which place the various lengths N 6, N 7, N 8 and N 9 in plan in Fig. 29, as shown by E 6, E 7, E 8 and E 9 on E A in Fig. 31. At right angles to E A draw E N, equal to E C in elevation in Fig. 29. Then from 6, 7, 8 and 9 in Fig. 31 draw lines to N, which will represent the true lengths on similar lines in plan in Fig. 29.

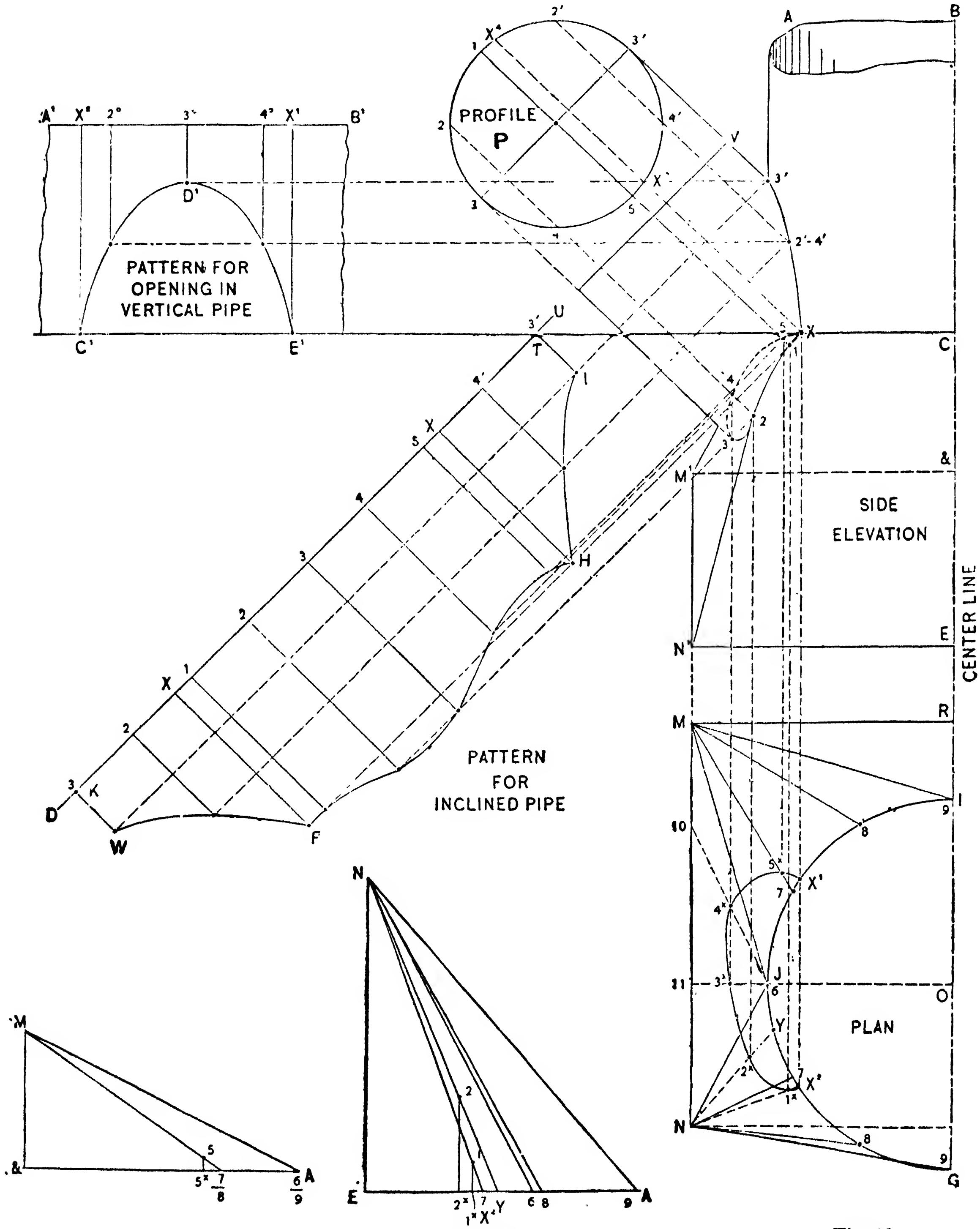


Fig. 31 Fig. 30 Fig. 29

Procedure for Obtaining Diagrams of Triangles and Patterns

For the pattern for the transition piece draw in Fig. 32 horizontal line N M, equal to E D in front elevation in Fig. 28; then using M 6 in Fig. 30 as radius and M in Fig. 32 as center describe the arc 6, which intersect by an arc struck from N as center and N 6 in Fig. 31 as radius. Draw a line from N to 6 to M in Fig. 32. Now, with N as center and radii equal to N 7, N 8 and N 9 in Fig. 31, describe the arcs N 7, N 8 and N 9 in Fig. 32. Now set the dividers equal to the spaces into which the half plan I J G in Fig. 29 is divided, and, starting from 6 in Fig. 32, step from one arc to another, thus obtaining the intersections 7, 8 and 9. Draw a line from 9 to N. Now, with 9 as center and E F in the front elevation in Fig. 28 as radius, describe the arc S in Fig. 32, which intersect by an arc struck from N as center and N S in plan in Fig. 29 as radius. Draw a line from 9 to S to N in Fig. 32 and trace a line from 9 to 6. With radii equal to M 7, M 8 and M 6-9 in Fig. 30 and M in Fig. 32 as center describe the arcs 7′, 8′ and 9′. Set the dividers equal to one of the spaces in the half plan I J G in Fig. 29, and, starting from the point 6 in Fig. 32, step from one arc to another, thus obtaining the points 7′, 8′ and 9. Draw a line from 9′ to M. Now, with M R in plan in Fig. 29 as radius and M in Fig. 32 as center, describe the arc R, which intersect by an arc struck from 9′ as center and C D in front elevation in Fig. 28 as radius. Draw a line from M to R to 9′ in Fig. 32 and trace a line from 9′ to 6. Then will 9 6 9′ R M N S be the half pattern for the transition piece.

For the pattern for the opening to be cut into the transition piece proceed as follows: As the point of intersection 5^x in the miter line in plan in Fig. 29 intersects the radial line 7 M, then take the distance from M to 5^x and place it in Fig. 30 on the line & A from & to 5^x. From 5^x erect a perpendicular line intersecting the slant line M 7 at 5. Take the distance from M to 5 and place it on the line M 7′ in Fig. 32 from M to 5, as shown. Now through the points of intersections in the miter line in plan in Fig. 29, 1^x and 2^x, draw lines to the apex N, extending them until they intersect the half circle at X^2 and Y, respectively. Take the distances of N X^2 and N Y and place them on the line E A in Fig 31 from E to X^2 and E to Y, respectively, and draw lines from X^2 to N and Y to N, which will represent the true distances on similar lines in plan in Fig. 29. Now take the distances from N to 1^x and N to 2^x and place them from E to 1^x and 2^x, respectively, in Fig. 31. From 1^x and 2^x erect perpendicular lines intersecting the hypotenuses X^2 N and Y N at points 1 and 2, respectively, as shown. Take the distance from 6 to Y and 7 to X^2 in plan in Fig. 29 and place it, as shown, from 6 to Y and 7 to X^2, respectively, in pattern in Fig. 32. From the points Y and X^2 draw lines toward the apex N. Then with N 1 and N 2 in Fig. 31 as

radii and N in Fig. 32 as center intersect the radial lines X^2 N and Y N at 1 and 2, respectively. Through the intersections 3^x and 4^x in the miter lines in plan in Fig. 29 draw lines to the point 6, extending them and intersecting the line M N at points 11 and 10, respectively. Take the distances from N to 11 to 10 to M and place them in the plan in Fig. 28, as shown from N to 11 to 10 to M. At right angles to N M draw the lines 11 11″ and 10 10″, intersecting F C and E D in front elevation at 11″ 10″ and 11′ 10′, respectively.

It will now be necessary to construct an extra set of triangles on 10 6 and 11 6 in plan in Fig. 29. In Fig. 33 draw any horizontal line, as A B, upon which place the lengths of 6 10 and 6 11 in plan in Fig. 29, as shown by 10 10′ and 11 11′, respectively, in Fig. 33. At right angles to A B and from 11′ and 10′ draw 11′ 6 and 10′ 6, equal in hight to 11′ 11″ and 10′ 10″, respectively, in front elevation in Fig. 28. Draw lines from 6 to 11 and 6 to 10 in Fig. 33, which will represent the true distances on similar lines in plan in Fig. 29. Now take the distances 11 3^x and 10 4^x in plan in Fig. 29

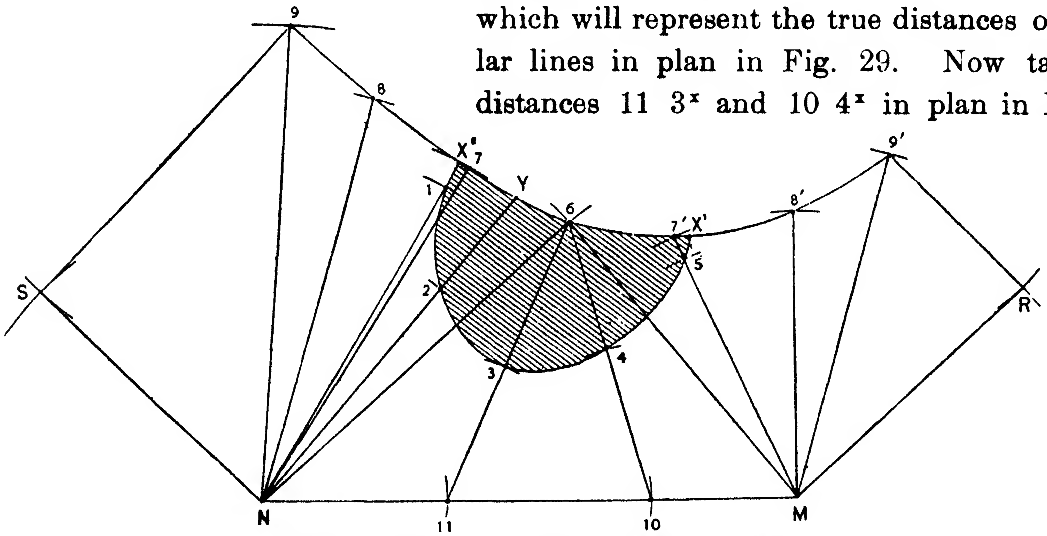


Fig. 32. Pattern of Transition Piece Showing Opening

and place them in Fig. 33 on the line A B, as shown from 11 to 3^x and 10 to 4^x, respectively. From 3^x and 4^x erect lines intersecting the slant lines 6 11 and 6 10 at 3 and 4. Take the distances in front elevation in Fig. 28 from E to 11′ to 10′ to D and place them in Fig. 32 from N to 11 to 10 to M, as shown. From 10 to 11 draw lines to the point 6. Then take

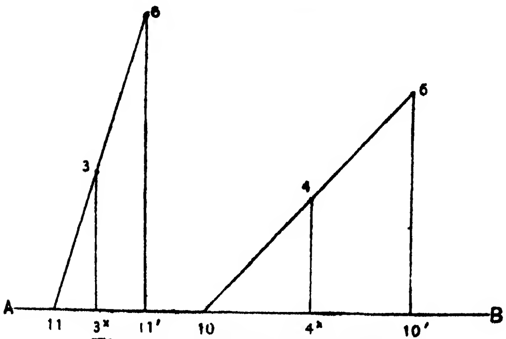


Fig. 33. Diagram of Triangles

the lengths from 11 to 3 and 10 to 4 in Fig. 33 and place them in Fig. 32 from 11 to 3 and 10 to 4, respectively, as shown. Take the distances from 7 to X^1

and 7 to X^2 in plan in Fig. 33 and place them, as shown, from 7 to X^2 and 7′ to X^1 in Fig. 32 respectively. Through the points of intersections X^2, 1, 2, 3, 4, 5 and X^1 trace a line, as shown. Then will the shaded portion be the part to be cut out of the transition piece to receive the inclined pipe.

PATTERN FOR TRANSITION PIECE OF PECULIAR FORM

It may be stated that in this, as, in fact, in all cases where more than one view of an object is required, "getting the correct views"—that is, the question of drawing—is of the utmost importance. A sufficient number of views which correspond with each other in every respect must be obtained before the patterns can be

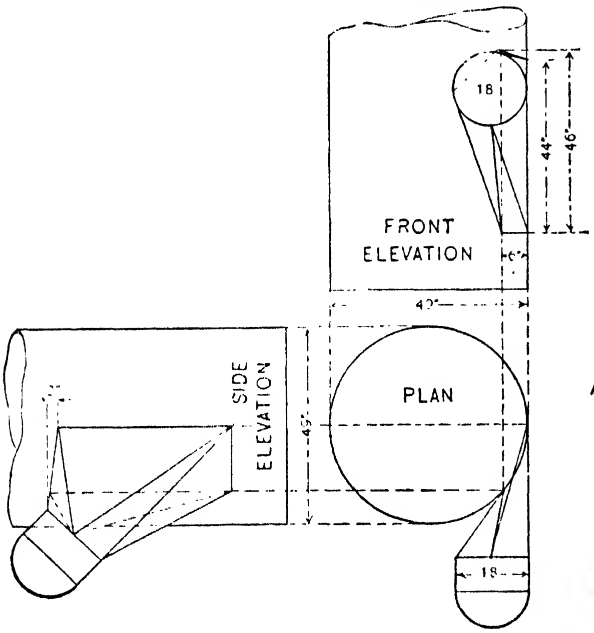


Fig. 34. A Sketch of the Problem

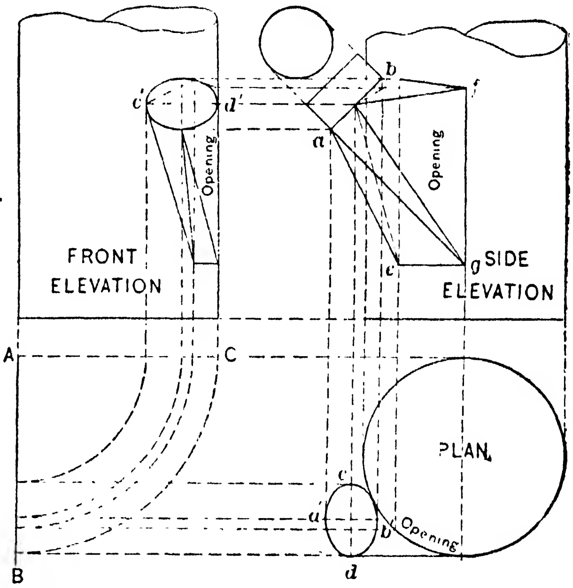


Fig. 35. Method of Projecting the Side Elevation from the Other Views

developed. The drawings which are shown to a reduced scale in Fig. 34, are in the preliminary work correctly projected. The 18-inch opening, however, in the front elevation should show elliptical, and the same may be said of this opening as it appears in the plan.

In Fig. 35 is shown another method of projecting the several views, from an inspection of which the method of arriving at the widths of the ellipses will be seen. Since the side elevation is, in this case, the principal one, the plan should first be drawn in such a position that the side of which the elevation is required will be turned toward the bottom of the paper, after which lines are carried upward

from its several points, as shown at the right in Fig. 35. With the plan and one elevation complete, the other elevation should be obtained by projections from both the other views. Although in this case the other or front elevation is not necessary so far as obtaining the patterns is concerned, it is here explained, since the method of obtaining it may be readily applied in numerous other instances.

The front elevation may, of course, be obtained by projecting it from the plan at right angles to the other elevation, as it is in Fig. 34; but if obtained by horizontal projections from the front elevation, as shown at the left in Fig. 35, the relative hights of the corresponding parts are more easily seen and obtained, as will be presently shown. This course will require either the drawing of another plan turned one-quarter around (that is, with its front toward the bottom of the paper), or the obtaining of the lateral widths by some other method. They may be obtained either by measurements made vertically across the plan and transferred to the front elevation, or by projection from the plan in the following manner, as shown in Fig. 35. Lines from the several points of the plan are carried horizontally to the left until they intersect a vertical line, A B, drawn at any convenient point, and are then carried around a quarter circle, the center of which, A, is taken at convenience on A B. Having thus reached the horizontal line A C, they are continued upward into the front elevation, as shown. In the construction of the drawings now, the lines *a b* of the side elevation and *c d* of the plan are each made equal to the full width of the small pipe (18 inches), the line *c d* being projected from the middle point of *a b*. Lines from *a* and *b* are now projected to cut the center line of the pipe in plan at *a′* and *b′*, thus giving the correct width of the ellipse in plan. Lines from *c* and *d* of the plan are also carried into the front elevation by the course above described, where they cut the horizontal line from the center of *a b*, as shown at *c′* and *d′*, giving the length of the ellipse, while lines from *a* and *b* are carried this time horizontally to the front elevation, to cut the center line of the pipe brought from *a′ b′* of the plan, thus giving the correct width of the ellipse in the front elevation.

Lines drawn from *b* to *f* and from *a* to *e* will complete the general outline of the transition piece. The position of the lines diverging from *g* will be determined in the subsequent process of triangulation.

A transition piece forming a connection between a round and a rectangular opening, under ordinary conditions, consists of four plane triangles and four quarter cones, more or less oblique, according to circumstances. The great difference, however, between the case under consideration and that of an ordinary transition piece lies in the fact that what in the present case has been called a

rectangular opening is, in fact, only rectangular as it appears in elevation. Since it is an opening in the side of a large cylinder, its ends are curved to the radius of the cylinder, and, furthermore, the position of the smaller pipe is found to be so very oblique with reference to the opening that, should an attempt be made to tri-

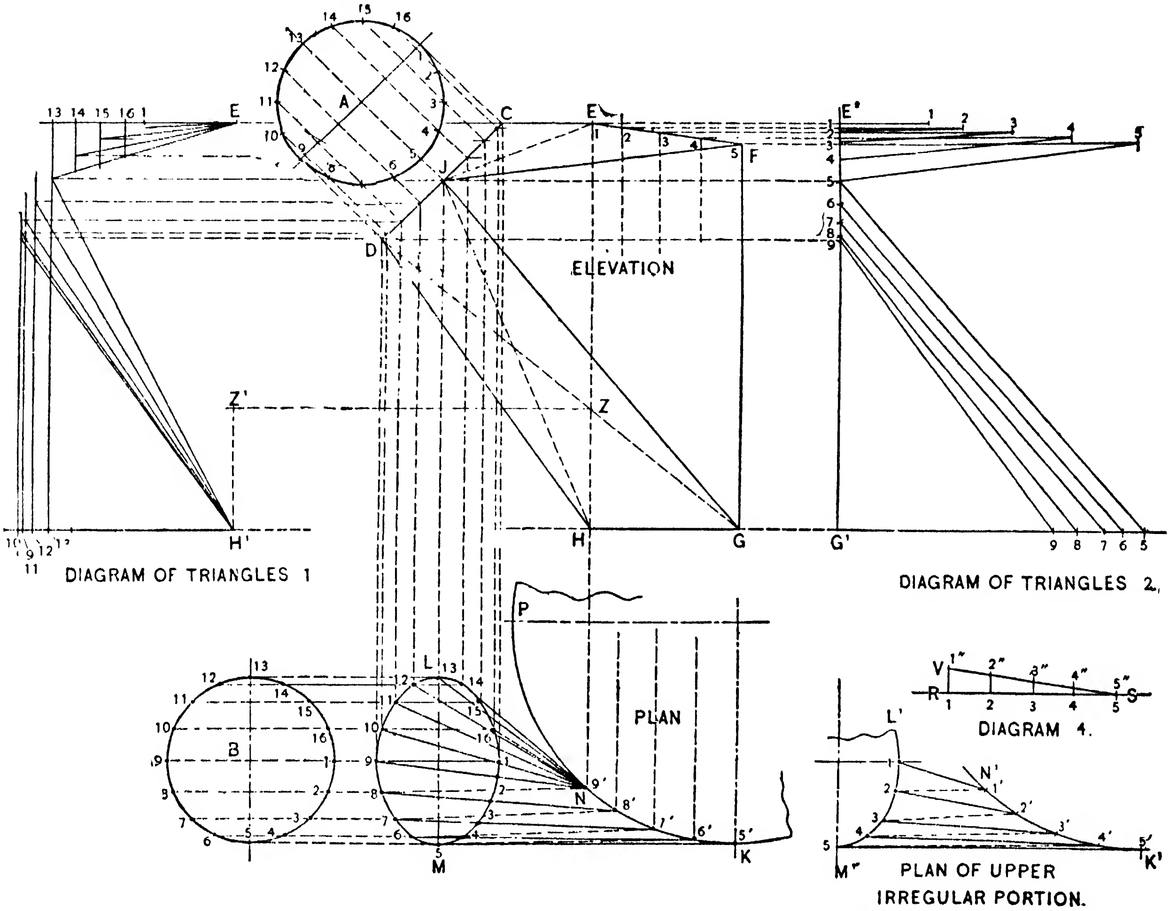


Fig. 36. Elevation and Plan of Transition Piece with Diagrams of Triangles Showing Method of Triangulation

angulate it according to the above subdivision, the curve of the cylinder would cut into the sides of two of the cones. This will be seen by reference to Fig. 36, in which E F G H shows to an enlarged scale the opening *b f g h* of Fig. 35, while D C, with its profile, A, corresponds with *a b* of the latter figure. In the plan the curve P K of the large cylinder has been drawn with a slightly shorter radius, comparatively, than in Fig. 35, so as to avoid confusion of lines.

A correct projection of the opening of the 18-inch pipe, as shown at L M of the plan, must be obtained before the work of triangulation can be begun, which

can be done in the following manner: First draw a profile of this opening in line with L M, as shown at B, and divide both profiles, A and B, into the same number of equal spaces, as shown by the small figures, being careful that point 1, the highest point of the opening, is correspondingly located in both, as shown. From the several points in profile A project lines at right angles to C D, cutting the same as shown. Now, from the several points in profile B project lines at right angles to L M indefinitely, which intersect with lines of corresponding number dropped vertically from the points previously obtained on D C. A line traced through the points of intersection, as shown by the corresponding small figures in L M, will give the required view of the opening in plan.

It will now be seen that the triangulation of the transition piece can be most conveniently accomplished by first dividing the circular opening into four equal parts, by the points 1, 5, 9 and 13 of profiles A and B, with a view of making each quarter the base of an oblique cone with an apex at the nearest angle of the large, or so-called rectangular, opening. Thus, that quarter between points 1 and 13 will form the base of a quarter cone, the apex of which is at E of the elevation or N of the plan, while that quarter from 13 to 9 will be the base of a cone the apex of which is at H of the elevation and which appears also at N of the plan. These two conical surfaces are connected by the plane triangle shown by J E H of the elevation and by L N of the plan, all these parts or elements forming what may be termed the back of the transition piece. If now it be attempted to carry out this method in the treatment of the front part, the quarter 1 5 would be taken as the base of a quarter cone the apex of which is at F of the elevation, and the cone would be shown by points 1, 5, K of the plan; but if a line be drawn from 1 to K of the plan (not shown), it will be cut by the circle P N K of the large cylinder somewhere near the point N, thus mutilating this conical portion, as above mentioned. The same may be said of the fourth conical surface, which would be shown by 9 5 K of the plan. It will therefore be better to consider that portion of the transition piece from 1 to 5 at its round end to E F of the elevation at the other end, as one irregular piece or element of the whole; and likewise that portion from 5 to 9 at the round end to G H at the large end as another similar element, thus leaving the large plane triangle J F G of the front side to complete the pattern.

With this separation of the transition piece into its elementary parts the operations of triangulation may be completed as follows: First draw lines from points 9, 10, 11, etc., to 1 of L M, to the point N of the plan. These lines will represent the horizontal distances of points 9 to 13 from H of the elevation, and of

points 13 to 1 from point E, and will be used as the bases of a series of right angled triangles, the hypotenuses of which, when obtained, will be the true distances between points of corresponding number on the finished article.

The triangles for the conical portion, the apex of which is at E, may most easily be obtained by extending E C of the elevation in either direction, as shown at the left of A, upon which set off from any point, as E^1, the lengths of the several lines in the corresponding quarter of the plan just drawn to point N, as shown by E^1 13, E^1 14, etc. Now, from the several points 13, 14, 15, etc., thus obtained, drop perpendiculars, which intersect by horizontal lines drawn from points of corresponding number on J C, previously obtained from profile A. Lines drawn from the several points of intersection to E^1, as shown, will be the required hypotenuses. The triangles for the lower conical portion may be obtained in a similar manner by using an extension of H G as the base. The lengths of the lines N 9, N 10, etc., of the plan are set off from any point, as H^1, as shown by the small figures 9 to 13, from which perpendiculars are erected and intersected by horizontal lines projected from points of corresponding number on D J. Lines drawn from the several points of intersection to H^1 will be the required hypotenuses for the lower cone.

To triangulate the lower irregular element above described, the line N K of the plan must first be divided into as many equal spaces as either quarter in the front half of L M—that is, into four spaces—as shown by the points 6′, 7′ and 8′ between N K or 5′ 9′ of the plan. Solid lines may now be drawn between points of corresponding number on L M and N K, and dotted lines from points 5, 6, 7 and 8 on L M, respectively, to points 6′, 7′ 8′ and 9′ on N K

The triangulation of the upper irregular piece is accomplished in exactly the same manner, and to avoid a confusion of lines its plan is shown at the right of the main plan, of which its curved lines are duplicates. The points in N^1 K^1 are numbered from 1′ to 5′ to correspond with those in the adjacent quarter of L^1 M^1. The several solid lines here shown together with those previously obtained on the main plan form the bases of the triangles in the diagram at the right of the elevation, while the triangles to be formed upon the several dotted lines of the plans are shown in a separate diagram in Fig. 37.

Since E F of the front elevation is an oblique line it will be necessary, in constructing a diagram of triangles for the upper irregular element of the transition piece, to project lines horizontally from each of the points on E F indefinitely to the right, as shown in diagram of triangles 2, upon which the lengths of the several solid lines of corresponding number of the plan are set off from the inter-

section of a common perpendicular E^2 G^1, thus locating points 1 to 5, shown at the right of E^2. Horizontal lines are now projected from points on J C as obtained from profile A, cutting E^2 G^1, as shown by the small figures. Lines drawn from these points of intersection to points of corresponding number at the right will give the hypotenuses for the solid triangles. Diagram 3 should properly be constructed at the right of diagram 2, the points on E^3 G^2 being obtained by a continuation of the projections from the elevation used in obtaining the points on E^2 G^1, but for lack of space it is shown separately in Fig. 37. The hypotenuses in Fig. 37 are drawn between numbers corresponding with those of the dotted lines of the two plans, as from 2 to 1, 3 to 2 and 5 to 6, 6 to 7, etc.

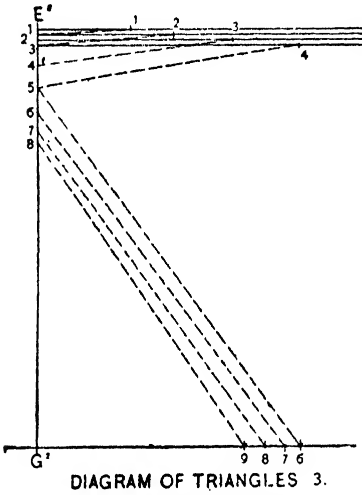


Fig. 37. Final Diagram

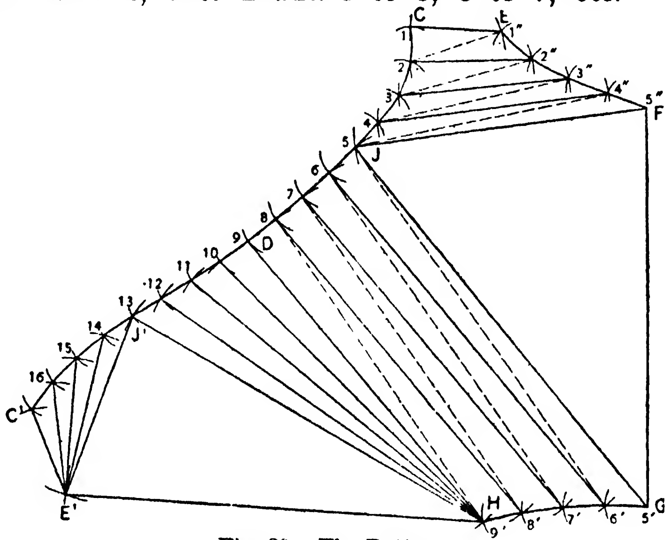


Fig. 38. The Pattern

In consequence of the obliquity of E F above mentioned it will be necessary to construct a small diagram, numbered 4 in Fig. 34, in order to ascertain the true distances between its points. Therefore on any line, as R S of diagram 4, set off a stretchout of N^1 K^1 just below, as shown by the corresponding figures, from each of the points in which erect a perpendicular. The hight of each perpendicular is made equal to the hight of corresponding points on E F above a horizontal line drawn from F but not shown, or is obtained from the projection of those points on E^2 G^1, as above described, and as also shown at T of diagram 3.

For convenience in laying out the pattern from the various dimensions now obtained it will be considered that the joint is to be made upon the line C E of the elevation; although the size of the piece will require several joints, the positions of which can most easily be determined after the pattern is developed as a whole. Therefore construct first the triangle J F G of the pattern, Fig. 38, which is an exact duplicate of the triangle designated by the same letters in the

elevation, Fig. 36. Now, with 5 4 of diagram 3, Fig. 37, as a radius and J of the pattern as center describe a short arc near 4″ of the pattern, which intersect with another arc the radius of which is 5″ 4″ of diagram 4, thus locating point 4″ of the pattern. With a radius equal to 4 4 of diagram 2 and from 4″ of the pattern as center describe a short arc, which intersect with another arc drawn from point J (5) of the pattern as center and with a radius equal to 5 4 of profile A, thus locating the position of point 4 of the pattern. Continue this operation, using the spaces of profile A in numerical order, as shown, for the side J C of the pattern, and those of V S of diagram 4 for the side F E, while the measurements across are taken alternately from the upper parts of diagrams 3 and 2, all as shown.

The lower irregular element of the transition piece may now be added to the pattern in exactly the same manner as above described for the upper part, beginning with J G of the pattern as a base, and using the lengths of the dotted hypotenuses from the lower part of diagram 3 with the distances from N K of the plan as radii to develop that part of the pattern from G to H, and the hypotenuses from the lower part of diagram 2 with the corresponding spaces on profile A as radii to develop that pattern from J to D, all as shown by the corresponding figures in the several views mentioned.

The lower conical element of the pattern may now be added by first describing arcs from H of the pattern as center with radii equal to the lengths of the several lines converging at H^1 of diagram 1, after which the spaces from 9 to 13 of profile A may be set off from D (9) of the pattern upon the several arcs, measuring or stepping from one arc to the next in numerical order, thus developing the line from D to J^1. The large triangle forming the back of the transition piece, shown by J E H of the elevation, may next be added in the following manner: From J^1 of the pattern as center, with a radius equal to E^1 13 of diagram 1, describe a short arc, and intersect the same with another arc, the radius of which is equal to H E of the elevation, thus locating the point E^1 of the pattern. The upper conical element is finally added, using as radii the lengths of lines converging at E^2 in the upper part of diagram 1 with the spaces from 13 to 1 of profile A, all as shown from J^1 to C^1. Lines traced through the several intersections of arcs from C to C^1, from E to F and from G to H will complete the pattern

PATTERN FOR A SPOUT HOPPER

Problems of this nature are termed transition pieces because, being usually made to form an intermediate joint or section between two pipes of different plans or profiles, they form a transition from one form to the other, and the principles involved in obtaining the pattern of any such piece are applicable to any other of that class.

If in making the joint at the bottom the vertical pipe is cut off square, the lower base of the transition piece will, of course, be a simple circle, but if it is cut off by an oblique plane, making the angle with the inclined and with the vertical portions approximately equal, as in an ordinary elbow, then a little more preliminary work will have to be done before the work of triangulation can be begun. In that case the ellipse produced by cutting the round pipe obliquely will have to be first developed.

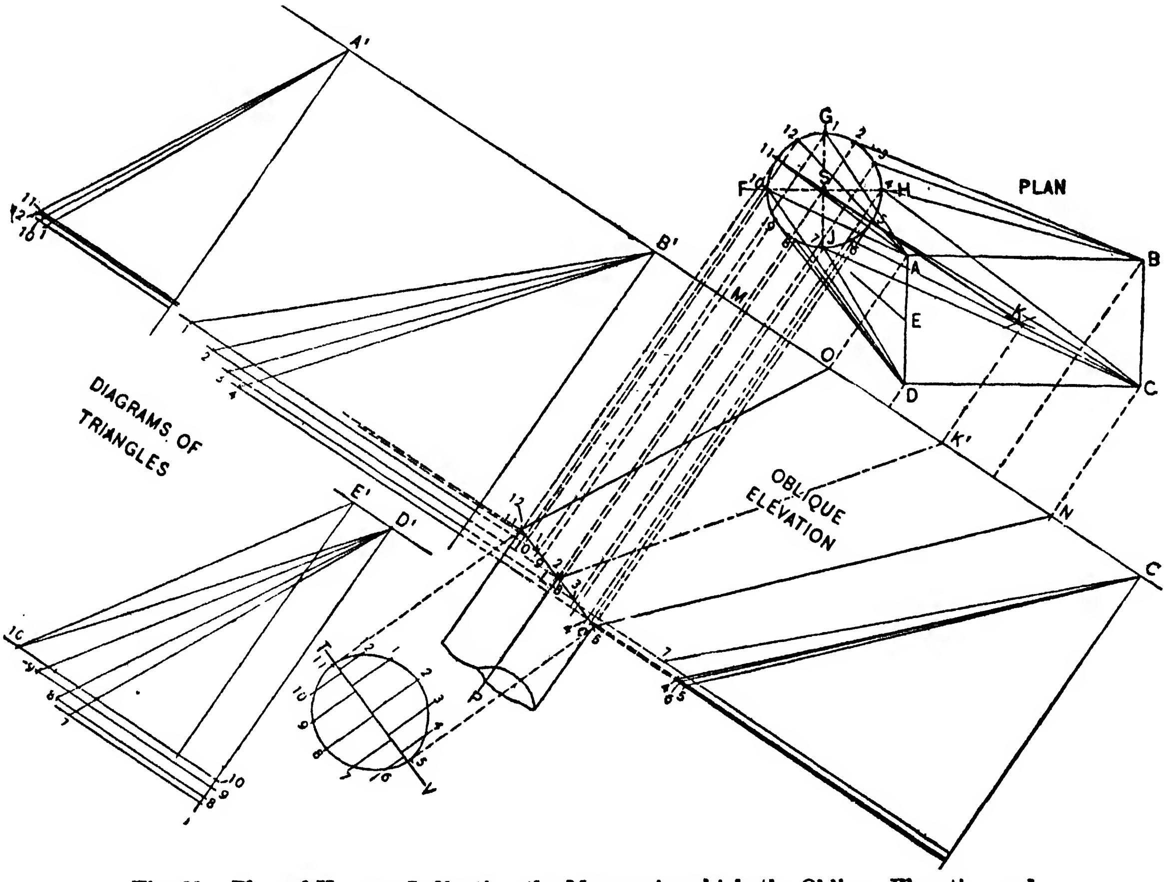


Fig. 39. Plan of Hopper, Indicating the Manner in which the Oblique Elevation and Diagrams of Triangles are Obtained

In Fig. 39 of the diagrams, A B C D represents a plan of the upper rectangular end of the hopper, while F G H J shows the relative position of the vertical pipe

with which its lower end is to miter. The proper way to obtain the correct angle of the miter between the hopper and the vertical pipe is to first construct an oblique elevation on a plane parallel to a line joining the centers of the two ends or bases in plan. Therefore, find the center of A B C D, as shown at K, and draw a line from K through the center of the round pipe shown heavy on the plan. Now, at any convenient position below the plan draw a line, as M N, parallel to the heavy line, and from each of the points A, B, C, D and K drop lines at right angles to M N, cutting the same, as shown. Also drop a similar line from the center of the round pipe of indefinite length, upon which set off from M N the required vertical hight of the hopper, as shown by M L, and draw L K^1. The angle K^1 L P will then be the correct angle between the vertical pipe and the hopper, and the miter line may now be drawn through L, so as to bisect this angle, just as though both arms of the miter were to be of the same profile. The lines of the sides of the pipe may now be projected from the plan, as shown, and from their intersections with the miter line, lines are drawn to the points O and N, corresponding to the angles A and C of the rectangle. This completes the general outlines of the elevation.

In completing the plan and determining the method of triangulation the plan of the round pipe must first be divided into quarters by the lines F H and G J, each quarter of which will form the base of a quarter cone the apex of which is at the corresponding corner of the rectangle. Thus, F G S is the base of one quarter of an oblique or scalene cone, the apex of which is at A, while G H S is a quarter of a different scalene cone, having its apex at B. In like manner J S H C and F S J D are the two remaining cones, each of the four differing from the others in the amount of its obliquity or slant. Between the envelopes or outer coverings of these four quarter cones four plane triangles exist, the bases of which are the four sides of the rectangular base and the vertices of which are at the points G, H, J and F; as A G B, B H C, etc. The triangles which form the sides of the transition piece may be said to be inverted with reference to the cones, the envelopes of which form the angles or rounded corners of the same.

Now, divide each quarter of the plan of the round pipe into any convenient number of equal spaces, as shown by the small figures, and draw lines from the points of division in each quarter to the corresponding apex, as shown. These lines represent in plan the division of each conical surface into three plane triangles, and the true lengths of these lines may be obtained by using them as the base of a series of right angled triangles, the hypotenuses of which when found will be the true distances as measured between corresponding points of the finished article. These triangles may be most easily constructed by projecting the hights from the oblique elevation, as shown at eace side of the same, one group being made for each of the four cones

to avoid confusion of lines. First drop lines from all of the points of division in F G H J parallel to M L, cutting the miter line drawn through L, and from the points on the miter line thus obtained draw horizontal lines (parallel to M N) indefinitely to each of the diagrams, as shown. From any points, as A^1, B^1, etc., on M N extended, draw perpendiculars, as shown, cutting the horizontal lines just drawn, and from their intersections with the perpendiculars set off on each the length of corresponding line of the plan. Thus, upon the lines drawn from points 1, 2, 3 and 4 on the miter line set off on each from the perpendicular B^1 the lengths 1 B, 2 B, etc., of the plan, as shown in the diagram, and finally draw 1 B^1, 2 B^1, etc., which distances will be the true distances across the pattern.

Had the vertical pipe been cut off square at L instead of obliquely the lengths of the several lines of the plan would have been set off from their respective perpendiculars upon a single line drawn through L, forming the bases of the several diagrams of triangles, and the hypotenuses drawn as before. In that case also the measurements for the lower edge of the pattern could have been taken directly from the spaces on plan F G H J. But since the oblique section necessarily has a longer perimeter than a right section, a true section on the miter line through L must be obtained.

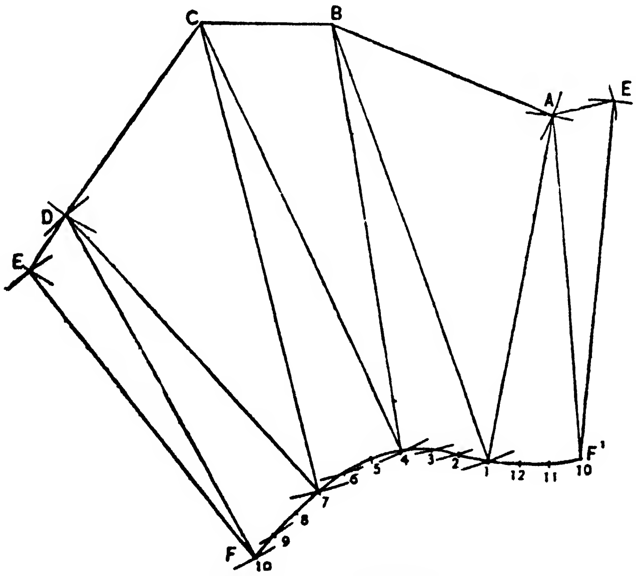


Fig. 40. The Pattern

To develop the section on the miter line first draw any line, as T V, parallel thereto, and from the several points on the miter line drop lines at right angles to T V, cutting the same, and extend them to one side or the other of T V to correspond with the lines of the plan F G H J with reference to the heavy center line. The lengths of the several lines are then made equal to corresponding lines of the plan, when a line traced through the several points thus obtained will give the required section.

To develop the pattern it is simply necessary to combine the dimensions now obtained, those of the elliptical section forming one side of the pattern and those of the plan of the rectangular base forming the other, while the distances across the pattern are taken from the diagrams of triangles. This part of the work will be very briefly described, because many patterns of this class have been given in the

book , and all patterns obtained by triangulation are developed in the same general manner after the preliminary dimensions have been obtained. The pattern may be begun with either of the large intermediate triangles, as that shown by B H C of the plan. First draw C B of the pattern, equal to C B of the plan; then with B^1 4 of the diagram of triangles as radius and C of the pattern as center describe a small arc, which intersect with another arc drawn from B of the pattern as center with a radius equal to B^1 4 of the diagrams, thus locating the point 4 of the pattern. The three adjacent triangles on either side of C B 4 have their apexes at C and B of the pattern. Therefore, from C of the pattern as center describe three arcs the radii of which are respectively C^1 5, C^1 6 and C^1 7 of the diagrams. Now, from 4 of the pattern as center describe a small arc with a radius equal to 4 5 of the section T V, cutting arc 5, and from the point 5 thus obtained in the pattern describe a small arc with a radius equal to 5 6 of the section T V, cutting arc 6, and establishing the point 6 of the pattern. In the same manner the point 7 of this group is obtained and also 3, 2 and 1 of the group on the other side of C B 4, the disances of which from B of the pattern are equal to B^1 3, B^1 2 and B^1 1 of the diagrams. The large intermediate triangles corresponding to the sides C D and B A of the plan are next constructed in the same manner as C B 4, after which the two conical surfaces the centers of which are at D and A of the pattern are described in the same manner as those centering at C and B, and the pattern is completed by the addition on either side of one-half of the triangle corresponding to A F B of the plan, the joint being made on the line E F.

PATTERNS FOR SHIP'S VENTILATOR OCTAGON IN SECTION

This article explains how to develop the patterns for a ship's funnel or ventilator made from lateral pieces, similar to the perspective view shown in Fig. 41. First draw the outline of the side elevation as shown in Fig. 42 by 1, 6, 19, 24, and divide at pleasure the heel and throat lines of the ventilator into any number of equal spaces, in this case five on the heel, as shown by 2, 3, 4, 5 and 6, and five in the throat, as shown by 20, 21, 22, 23 and 24. Connect these points, as shown from 2 to 23, 3 to 22, 4 to 21 and 5 to 20. These lines represent a series of planes on which true sections must be found. Knowing these true sections, assume that each section as 1, 2, 23, 24; 2, 3, 22, 23; 3, 4, 21, 22; 4, 5, 20, 21; 5, 6, 19, 20 in the side elevation is a transition piece, with the various semi-profiles on either end. The true section on the line 1 24 in the side elevation in Fig. 42 is shown

drawn in its proper position by C D E F 24, 13, 12 and 1. Through the center of this section draw the two diameters as shown, and directly in the center of these two lines draw the true octagon G H I J 19, 18, 7, 6, which represents the true section on the line 6 19 in the side elevation. In practice it is only necessary to draw the half sections.

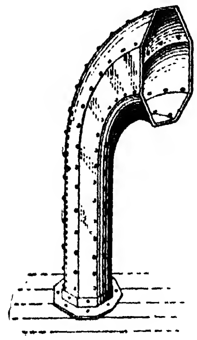


Fig. 41
Perspective of Ventilator

Now draw lines from the corners 1 to 6, 12 to 7, 13 to 18 and 24 to 19. Bisect each one of the planes in the side elevation, as shown by *a b c d e* and *f*. Take the distances from *b* to 2, *c* to 3, *d* to 4 and *e* to 5 and place them on the center line A° E° in the sections, measuring from and above the center point *h* and draw horizontal lines until they intersect the line 1 6 at 2, 3, 4 and 5 respectively. In a similar manner take the distances in the side elevation from *b* to 23, *c* to 22, *d* to 21 and *e* to 20 and place them on the center line A° E° measuring from and below the point *h*, and draw horizontal lines until they intersect the line 19 24, at 23, 22, 21 and 20 respectively.

Before the widths through the center points *b c d* and *e* in elevation can be found, a one-half vertical section through *a f* in elevation must be found as follows: At pleasure draw any vertical line alongside of the side elevation as shown by A^1 B^1 and from the various intersections *a b c d e* and *f* draw horizontal lines intersecting the vertical line A^1 B^1 as shown. Take the distances from *h* to *a* *h* to *f* in the sections, and place them as shown respectively by A^1 *a* and B^1 *f* in the vertical section. At pleasure draw the curved line from *a* to *f*, intersecting the horizontal lines previously drawn at *b c d* and *e*. These points, when measured horizontally to the center line A^1 B^1, give the true semi-widths through similar lettered points in the side elevation.

Measuring from the center line A^1 B^1 take the various distances to points *b c d* and *e* and place them in the sections, measuring from the center point *h*, as shown by *b c d* and *e*. Through these points at right angles to *h a* draw lines intersecting the line 12, 7 from 11 to 8 and intersecting the line 13, 18, from 14 to 17 respectively. From the various points on the line 12, 7, connect lines to the points on the line 1, 6. In a similar manner from the various points on the line 13, 18, connect lines to points on the line 24, 19. This diagram of sections then represents a series of 6 sections on the 6 planes shown in the side elevation by similar numbers.

The next step is to obtain the miter lines 7 12 and 13 18 in the side elevation. These are obtained by taking the distances in the diagram of sections from *b* to 11, *c* to 10, *d* to 9 and *e* to 8 and placing them on the planes in the side eleva-

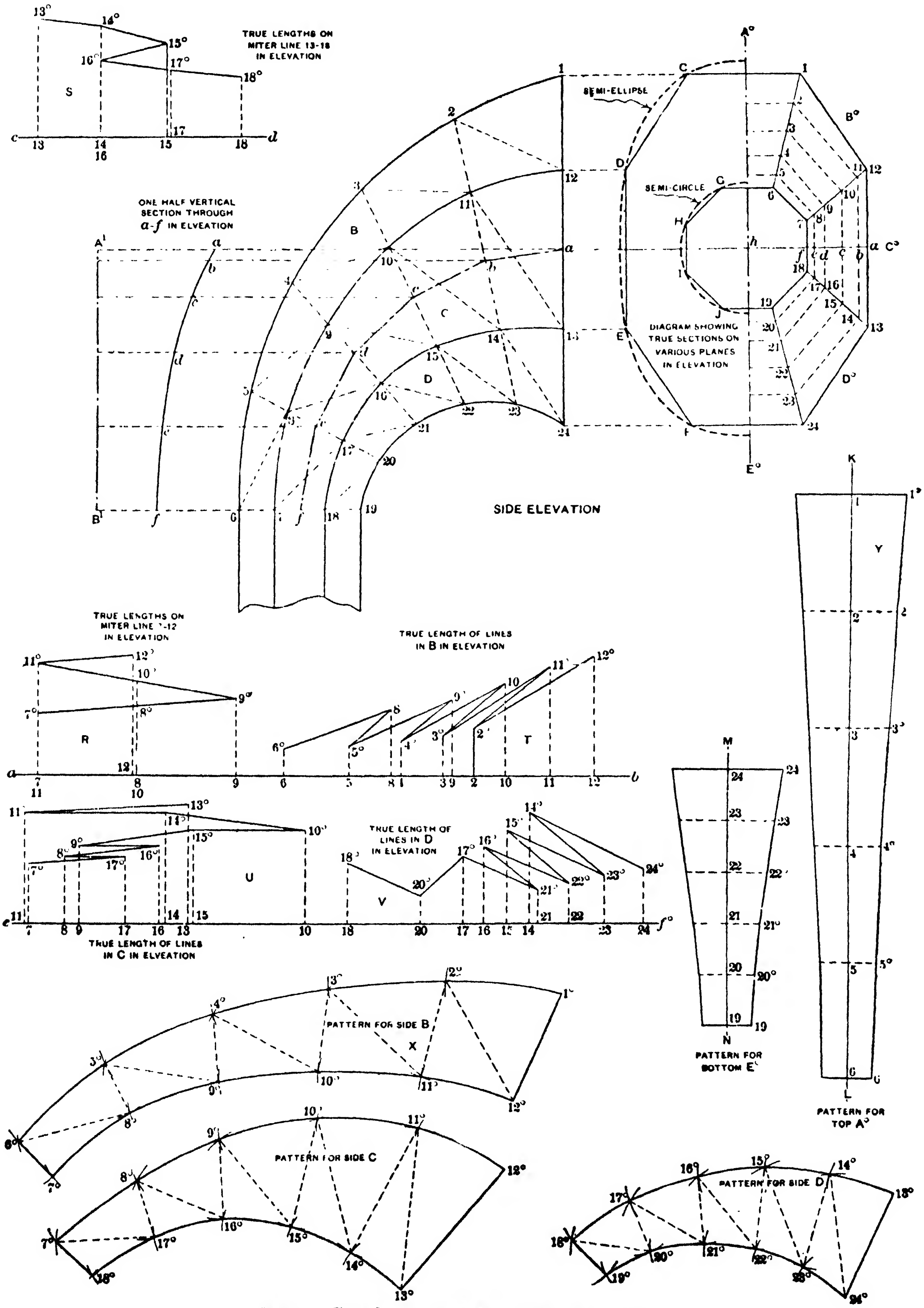


Fig. 42. Complete Process for Obtaining Patterns

tion from *b* to 11, *c* to 10, *d* to 9 and *e* to 8 and tracing a curved line as shown from 7 to 12. In a similar manner take the distances in the diagram of sections, from *b* to 14, *c* to 15, *d* to 16 and *e* to 17 and place them in the side elevation as shown from *b* to 14, *c* to 15, *d* to 16 and *e* to 17 and trace a curved line from 13 to 18. This completes the side elevation of the ventilator.

Draw the diagonal connecting lines in the side elevation as shown from 2 to 12, 3 to 11, 4 to 10, etc., until the last line 14 to 24 is drawn. The various solid and dotted lines in the elevation must then be considered as bases of sections the altitudes of which are found in the various horizontal distances in the diagram of sections to the right of the center line A° E. The true length of the curve 1 6 in the elevation on its miter line will be found when the pattern for the top is developed, while the true length of the curve 19 24 on its miter line will be found when the bottom pattern is laid out.

To obtain the pattern for the top of the ventilator marked A° in the diagram of sections proceed as follows: Take the girth of the outer curve 1 to 6 in the side elevation, and place it on the vertical line K L as shown by similar numbers, through which points, at right angles to K L, draw lines indefinitely. Measuring from the center line A° E° in the diagram of sections take the various distances to points 1, 2, 3, 4, 5 and 6 and place them on similar numbered lines in the pattern for top, measuring on either side of the center line K L. A line traced through points thus obtained will be the pattern for the top of the ventilator and the miter cut shown from 1° to 6° will give the true edge line of the upper curve of the lateral piece B in the side elevation.

To obtain the pattern for the bottom of the ventilator, take the girth of the lower curve 19 24 in the side elevation and place it on the line M N as shown by similar numbers, through which draw the usual measuring lines. Measuring from the line A° E° in the diagram of sections, take the various distances to 19, 20, 21, 22, 23 and 24 and place them on similar lines in the pattern for the bottom, measuring on either side of the center line M N. A line traced through the various intersections will be the pattern for the bottom marked E° in the diagram of sections and the miter cut 19° 24° in the pattern for bottom will be the true edge line of the lower curve of the lateral piece marked D in the side elevation.

To obtain the true lengths on the miter line 7 12 in the side elevation, take the distances from 7 to 8, 8 to 9, 9 to 10, 10 to 11 and 11 to 12 and place them on any horizontal line as *a b*, as shown from 7 to 8, 8 to 9, 9 to 10, 10 to 11 and 11 to 12. It will be noticed that the lengths are placed backward and forward over one another, so as to take up little space. At right angles to *a b* through the var-

ious points 7 to 12 erect perpendiculars as shown, making them equal to the horizontal distances in the diagram of sections, measuring in each instance from the line A° E° to points 7, 8, 9, 10, 11, and 12 respectively. For example, to make this perfectly clear, the distance of 7 8 in the side elevation has been placed on the line *a b* as shown from 7 to 8 in R. From points 7 and 8 in R perpendiculars are erected as 7 7° and 8 8°, equal respectively to the horizontal distances measured from the line A° E° in the diagram of sections to points 7 and 8. The distance from 7° to 8° in R then represents the true length of the line 7 8 in the side elevation. In precisely the same manner obtain the true lengths of the miter line 13 18 in elevation, as shown in the diagram S, by similar numbers on the line *c d*, the various hights in S are obtained from the horizontal projections measured from the line A° E° to similar numbers in the diagram of sections.

To obtain the true lengths in the lateral side B in the side elevation, take the various distances from 12 to 2, 2 to 11, 11 to 3, 3 to 10, 10 to 4, 4 to 9, 9 to 5, 5 to 8 and 8 to 6 and place them on the line *a b* in T, as shown by similar numbers, placing one distance over another as from 12 to 2, 2 to 11, 11 to 3, etc., so as to save space. From the various points vertical lines are erected, equal to the horizontal distances in the diagram of sections, when measured from the center line A° E° to similar numbers. For example, to find the true length of 4 10 in B in the side elevation, take this distance and place it as shown by 4 10 in T, from which points erect the perpendiculars 4 4° and 10 10°, equal respectively to the horizontal distances measured from the line A° E° in the diagram of sections to points 4 and 10. The distance 4° 10° in T then becomes the true length of similar numbered line in the side elevation. In this manner all the true lengths in B are obtained.

The true lengths in the lateral pieces C and D in the side elevation are obtained in a similar manner as shown by similar numbers on the line *e f°* in the diagrams U and V respectively. The true lengths having all been obtained, the patterns may now be laid out.

To obtain the pattern for the lateral piece shown by B in the side elevation or B° in the diagram of sections proceed as follows: Take the distance from 1 to 12 in the diagram of sections and place it on any line as 1° 12° in the pattern for side B, which will hereafter be called X. With 1° 2° in the pattern Y as radius, and 1° in X as center, describe the arc 2° which intersect by an arc struck from 12° as center, with 12° 2° in the true lengths in T as radius. With a radius equal to 12° 11° in R, and 12° in X as center, describe the arc 11°, which intersect by an arc struck from 2° as center and 11° 2° in T as radius. Proceed in this man-

ner, using alternately first the divisions in the miter cut in Y, then the true length of the proper number in T; the true length of the proper line in R, then the true length of the proper number in T; the true length of the proper line in R, then the proper length from T, until the last line 6° 7° in X has been obtained, which is taken from 6 7 in the diagram of sections. A line traced through points thus obtained as shown from 1° to 6° to 7° to 12° in X will be the pattern for the two sides marked B in the side elevation.

When obtaining the pattern for the side C, the outer edge lines from 7° to 12° in C are obtained from similar numbers in the pattern X, while the lower edge lines 13° to 18° in pattern for side C are obtained from the true lengths in diagram S and the lengths of the connecting diagonal lines in the pattern for side C are obtained from the true lengths in diagram U. The edge lines from 13° to 18° in the pattern for the side D are obtained from similar numbers in the pattern for C. The edge lines from 19° to 24° in the pattern for side D are obtained from similar numbers in the miter cut in the pattern for the bottom E°, while the lengths of the diagonal connecting lines in the pattern for the side D are obtained from the true lengths in the diagram V. In both the patterns C and D the lengths of 12° 13° and 7° 18° in the former, and 13° 24° and 18° 19° in the latter, are obtained respectively from lines having similar numbers in the sides C° and D° in the diagram of sections.

Laps must be allowed for wiring at the mouth as well as for riveting the lateral pieces together, and if it is desired that the ventilator be made from round to elliptical, then the various patterns can be raised by means of the raising hammer to the desired shape, as is shown by the dotted lines in the diagram of sections.

PATTERN FOR A DIAMOND BOSS

The following deals with the method of how to obtain the pattern for the diamond boss shown in Fig. 43. B D shows part of the can, F E the diameter of the faucet and T U the extreme length of the boss. Directly below the elevation is the plan view of the boss, as shown by G C U J. Draw G U and C J. From K, as a center, draw the circle L S P N, representing the section on F E. Draw the diagonals T O and R M. As the four sides are alike it will only be necessary to develop the pattern for C S P U. Therefore divide the quadrant S P into four equal spaces, as shown by S 1, R 2 and P. In similar manner divide the profile of the can C U in elevation into equal spaces, as shown by C, 3, 4 and

U, and from these points drop lines intersecting C U in plan at C, 3, 4 and U. Draw lines from C to 1 and R; from R to 3, 4 and U, and from U to 2 and P. Then will these lines represent the bases of triangles which will be constructed with altitudes equal to various hights in elevation.

The reader should bear in mind that all the spaces contained in the circle in plan are on F E in elevation, while all the spaces contained in the side of the boss C U in plan are C U in elevation. Extend F E as F U^1, and from the various points C, 3, 4 and U in elevation draw horizontal lines, as shown. Take the various distances in plan as C S, C 1 and C R, and place them on F U^1, as shown by C S, C 1 and C R. From C erect C C^1, intersecting the line drawn from C in elevation. Draw lines from C^1 to S, 1 and R, which lines are the true lengths on similar numbers in plan. At any point, as R on the line F U^1, erect R R^1, cutting the line drawn from U in elevation. Take the various distances in plan from R to 3, R to 4 and R to U and place them in the diagram of triangles, measuring in each instance from the line R R^1 to similar numbered lines, as shown by 3, 4 and U, from which points draw lines to R. In similar manner erect U^1 U and set off U^1 P and U^1 2, equal in length to U P and U 2 in plan. Then draw lines in the diagram of triangles, as shown, from 2 and P to U. This completes the triangles necessary for the development of the pattern.

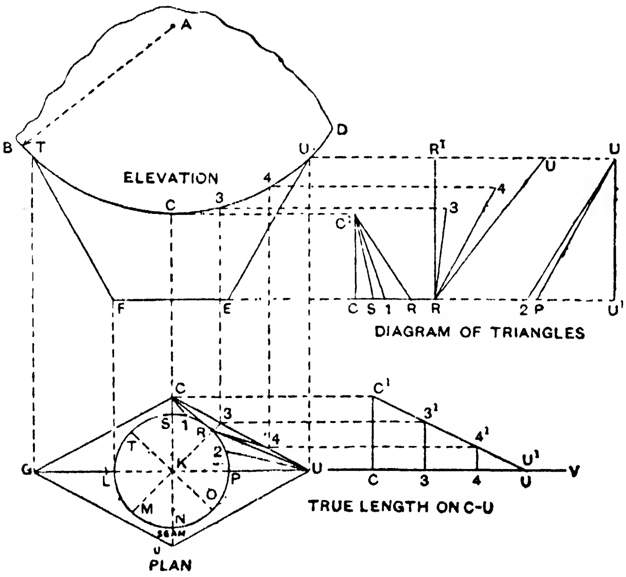


Fig. 43. Preliminary Work

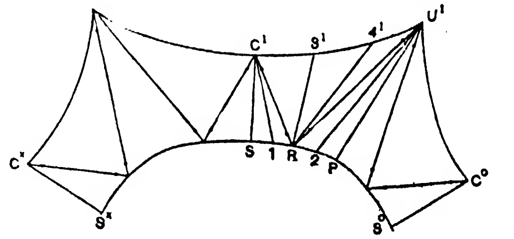


Fig. 44. The Full Pattern

The next step is to obtain the true length on C U in elevation, for which proceed as follows: Extend G U in plan as C U, upon which place the stretchout of C U in elevation, as shown by similar figures on U V. From C, 3, 4 and U on U V erect lines which intersect by horizontal lines drawn from C, 3, 4 and U in plan, resulting in the intersections C^1, 3^1, 4^1 and U^1. Connect these points, obtaining the true length on C U in elevation.

For the pattern draw any line, as C^1 S, in Fig. 44, equal to C^1 S in the diagram of triangles in Fig. 43. With radii equal to C^1 1 and C^1 R and C^1 in Fig. 44 as center, describe the arcs 1 and R. Set the dividers equal to the spaces in S R in plan in Fig. 43, and, starting from point S in Fig. 44, step from S to arc 1 to arc R and draw lines from 1 and R to C^1. With radii equal to R 3, R 4 and R U in the diagram of triangles in Fig. 43 and R in Fig. 44 as center, describe the arcs 3^1, 4^1 and U^1. Set the dividers equal to the various spaces C 3, 3 4 and 4 U in plan in Fig. 43, and, starting from C^1 in Fig. 44, step to arc 3^1, 4 and U^1, respectively, and draw lines from these points to R. Finally, with radii equal to U 2 and U P in the diagram in Fig. 43 and U^1 in Fig. 44 as center, describe the arcs 2 and P, which intersect by lengths obtained from the divisions in R P in plan in Fig. 43. Draw lines from 2 and P to U^1 in Fig. 44. Then C^1 U^1 P R S is the one-quarter pattern. If the pattern is desired in two parts trace opposite the line U^1 P, as shown by C° S°. If the boss is desired in one piece, with a seam at J N in plan in Fig. 43, trace the half in Fig. 44 opposite C^1 S, as shown.

PATTERN FOR A GARBAGE CHUTE

The following is the method of developing the pattern, in one piece, with seam on S T, having the square and round bodies in one piece, of what is termed a garbage chute. The square opening is to have a lid.

In connection with this problem, it must be said that while the pattern can be in one piece, another seam is necessary as at A' $4''$. Only the manner of obtaining the net pattern is exemplified. The allowing of laps for seams and method of joining the round collars and the making of the lid are governed by the gauge of material and the mode of manufacture. The lid pattern is simply a rectangular piece large enough to cover the 9×12-in. opening.

The procedure is as follows: Draw a 9-in. circle W to represent the pipe in plan. As the square body will be 9 in. wide, extend lines from the side of the circle. Project lines upward from the circle to be the sides in elevation of round body. From the center point o' on the line S $4'$ with the 45-deg. triangle draw the line O' B' indefinitely. Placing the triangle opposite to the position it had when drawing line O' B', move the triangle along till a point as A' is 12 in. from B' and outside the side line $4'$ $4''$ of the round body. It is understood, of course, that the design of this square body is a matter of choice, guided only by the requirement that design must permit of being made in one part. Connect

point A′ with 4″ and point B′ with 4′, thereby completing the elevation. Drop lines from B′ and A′ to the plan and connect points B′ and C with O; also points A and D with 4, giving the plan.

Divide circumference of circle into equal parts as shown, and project these points to the elevation. The next step is to ascertain the true length of lines, as B 1, A 7, etc. Therefore project lines to the side as indicated from points 4″ and A′ and from B′ and 4′. Place points B″, X, A″ and Y on the line from X and Y, place the distances in plan as B 1, A 7, etc. Connecting in diagram M and P with points B″ and A″ gives the true lengths of the lines.

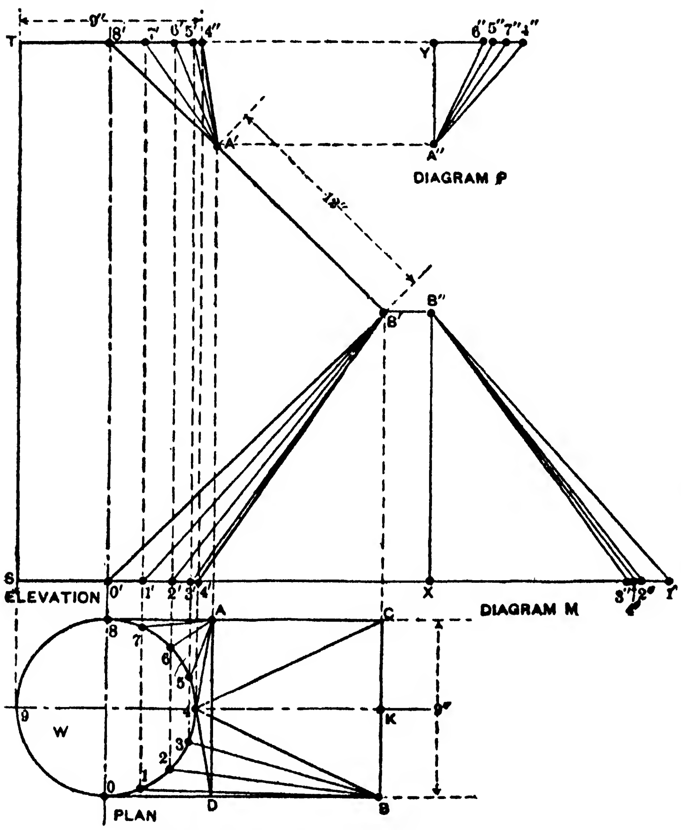


Fig. 45. Method of Obtaining Measurements for Patterns

For the pattern draw any line as 4 B of Fig. 46, of a length equal to 4″ B″ of diagram M, Fig. 45. On the compasses take the distances in plan B C and from B of the pattern draw an arc. Swing line B 4 to this arc, which gives point B′. With points B and B′ as centers and the compass set to diagram M, strike small arcs, and on these arcs with the bow dividers adjusted to the space 0 1 of the plan step the stretchout of the profile W. The distances O B and 8 B′ was taken from 0′ B′ of the elevation.

With compasses set to B′ 8′ of the elevation and from points B and B′ strike small arcs. From 0 and 8 on these arcs place the distance 0′ 8′ of the elevation, giving in the pattern a duplicate of 0′ B′ 8′ of the elevation.

At right angle to the lines 0 0 and 8 8 draw lines on which are stepped the stretchout of profile W from 0 to 9, which can be accomplished in this case by using the space 0 1 four times.

From points 0′ and 8′ on lines 8 B′ and B 0, place the distances 8′ A′ of the elevation. With these points A and A as centers and compass set to diagram P strike arcs on which are stepped the distance 0 1 of profile W. From

4' and 4' draw arcs, taking the distance 4" A' of the elevation. From A and A, with the dividers spanning B K of the plan, prick the space on the arcs

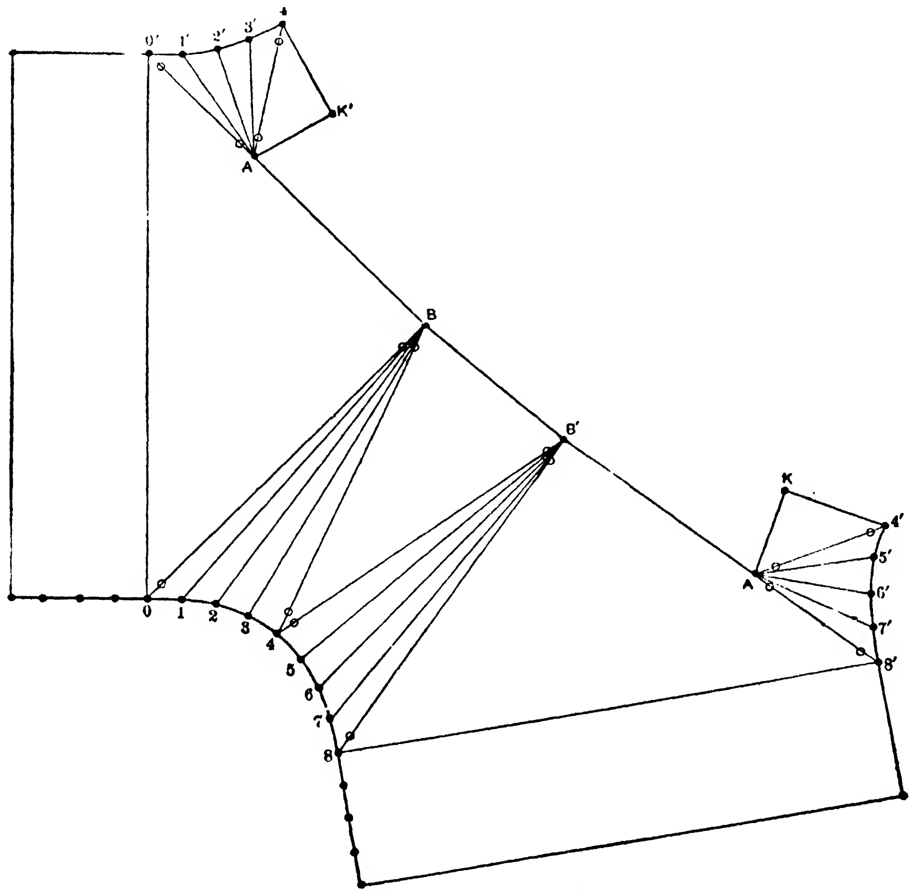


Fig. 46. Pattern for the Garbage Chute

obtaining points K and K'. This now is the pattern in one piece of the required article.

PATTERN FOR A CONCAVE SPIRAL CONVEYOR

The helical slide problem is of great interest to pattern cutters, and the following tells how to obtain the patterns for a concave so-called spiral conveyor when the center shaft is 8 in. in diameter as shown in the finished view in the accompanying illustration, Fig. 47 and the spiral conveyor has a projection of 18 in. with the surface concave upward as shown, with a vertical ledge 6 in. high. The hight of one revolution indicated by A has not been given, which can, however, be any desired measurement.

In this connection it is proper to say that the various lines of curvatures in the spiral represent various sections through a solid, and therefore only an approximate pattern can be developed, which will require some considerable skill with the stretching hammer to bring it to the desired shape. As the diameter from outer to outer edge of the conveyor measures 3 ft. 8 in., it is advisable to make a small model of clay, taking in, say, one-eighth of a revolution of the helix, and from this clay model make a female die of plaster paris. This plaster paris model is given a coat of shellac, when it can be sent to the foundry and an iron model cast, or if sufficient scrap zinc is at hand a die can be cast from zinc. After having the iron die made a male die is cast of lead.

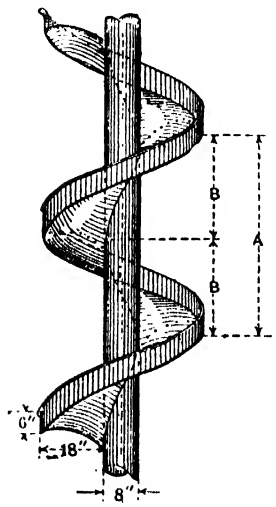


Fig. 47. View of finished Concave Conveyor

Then, using the lead die as the base and the iron die as the top, the various pieces can be stamped, using a hard piece of a wooden slat to lay over the iron die, while a small sledge furnishes the stamping power. While this method is crude, it answers the purpose when the job is small.

Of course where a considerable number of revolutions are needed, the work can be done more cheaply and accurately by sending measurements to any sheet metal stamping concern who will furnish estimates and guarantee an accurate fit along joints and intersections.

Assuming that the job is small and that it is desired to hammer up this work by hand in short sections, with the 6-in. vertical ledge in long sections, the method of obtaining the approximate pattern for the helix and the accurate pattern for the ledge is as follows:

Using A in plan as center, Fig. 48, describe the 8-in. circle, make the distance from 8 to 8′ 18 in., and with A as center and A 8′ as radius describe the outer circle. Divide the outer semi-circle in equal spaces (the closer the spaces the more accurate the pattern), in this case 8, as shown from 0′ to 8′, from which points draw radial lines to the center A, cutting the inner circle, as shown, from 0 to 8.

Draw the elevation of the center shaft as shown, and parallel to it draw any line as B C. As only a one-half revolution of the spiral will be shown in elevation, set off on B C, a distance 0 8, which will be equal to the hight of the desired half revolution, such as indicated by B in the finished view. As the semi-circle in plan has been divided into eight parts, then also divide the half revolution 0 8 on the line B C into eight equal spaces as shown.

From these points 0 to 8 at right angles to B C draw horizontal lines as shown, which intersect by lines drawn vertically from points 0 to 8 in the plan of the shaft. Trace a line through these intersections, as shown from D to E,

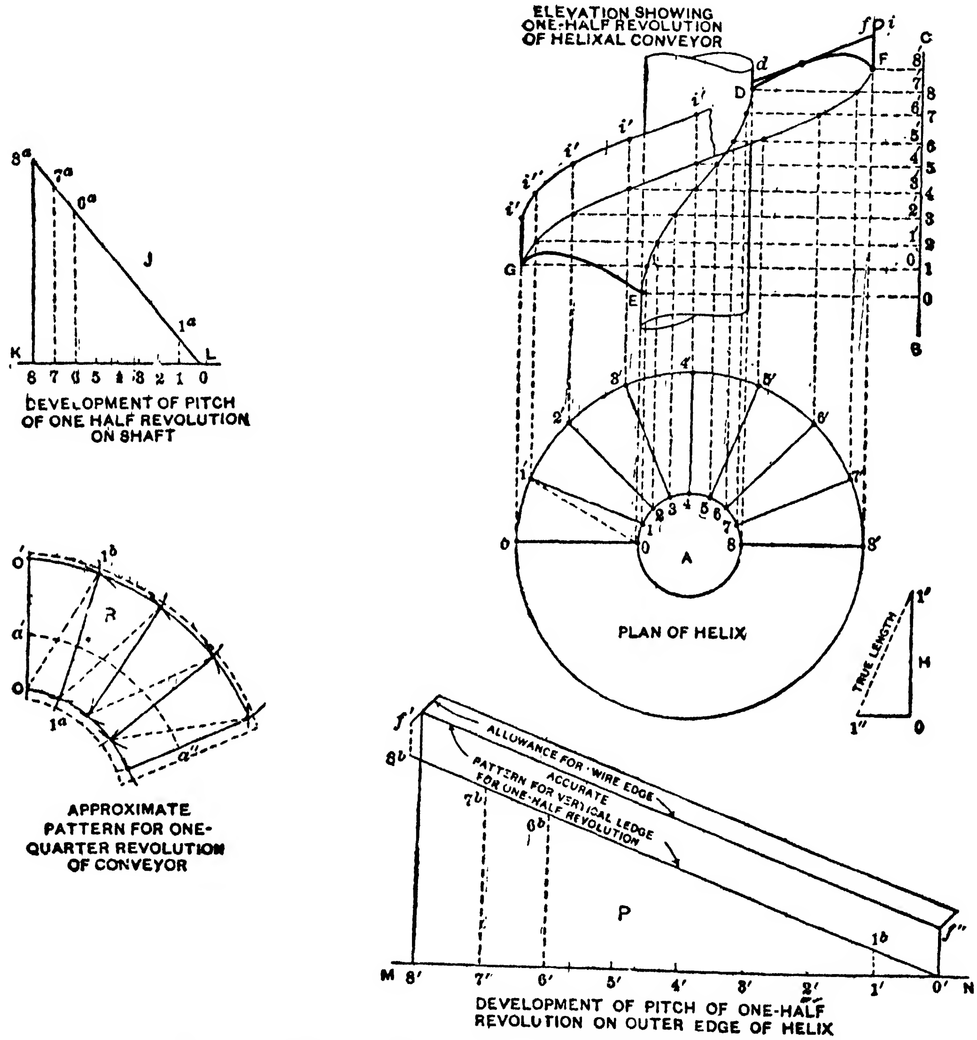


Fig. 48. Details of Pattern for a Concave Spiral Conveyor

which will, as can be seen, indicate the intersecting joint between the shaft and helix. Continuing further, from D draw the profile of the conveyor as shown from D to F to *i*.

From F draw a horizontal line, cutting the line B C at 8′, and from 8′ set off on the line C B the eight divisions from 8′ to 0′, equal to the divisions from 8 to 0, also on C B. At right angles to C B from points 0′ to 8′ draw horizontal lines, intersecting vertical lines erected from 0′ to 8′ in plan. A line traced from F to G will show the outer edge of the helix in elevation along the lower

edge of the ledge at F. If the hight from F to *i* is set off on the vertical lines just erected from the plan, as from G to *i′*, and as indicated by the point *i′*, they will give the upper line of the wired edge of the ledge in elevation. These helical lines just obtained are not necessary so far as the pattern is concerned, but are shown here, so that in case, which is seldom in practice, it becomes necessary to make a completed view, as shown in the illustration, the method of projection will be understood.

As this concave helical surface is, in a measure, similar to a curved molding, a line must be averaged through the profile D F, which will give the proper flare and the proper girth or amount of material to make up the mold or concave D F. In drawing the averaged line or flare no rule can be given, as the nature of the mold must determine the pitch of the line *d f*. In this case the pitch or averaged line has been drawn as shown by *d f*, touching the mold at *a*. Measuring from *a*, obtain the girth of *a* D and *a* F, and place it as shown respectively by *a d* and *a f*.

In developing the approximate pattern, triangulation will be employed; therefore the length of *d f* in elevation shows the true length of the solid line shown in plan. The true length to opposite points in plan, as from 0 to 1′, must now be found by taking the distance of 0 to 1′ in plan and placing it in diagram H, as shown from 0 to 1′; from 0 erect the perpendicular 0 1″, equal to the vertical hight 0 1′ or two spaces on the line B C in elevation. A line drawn from 1′ to 1″ in H will be the true length of the dotted line in plan.

The next step is to find the true pitch of the one-half revolution of the helix around the shaft. On any horizontal line, as K L in diagram J, place the girth of the small semi-circle in plan, as shown by similar numbers on K L, at right angles to which, from point 8, erect the perpendicular 8, 8^a, equal to 0 8 on the line B C. Draw a line from 8^a to 0 in diagram J and from point 1 erect the perpendicular, cutting the pitch line at 1^a. 0 1^a then gives the true length of one of the spaces against the shaft in elevation as E to 1. In diagram J perpendiculars have also been drawn from points 6 and 7, giving the intersections 6^a and 7^a and shows that but one space is necessary, as they are all equal to 1^a 0.

The true length along the outer edge of the helix from F to G in elevation must now be found as follows: Upon any horizontal line as M N in diagram P, place the girth of the large semi-circle in plan (which represents the plan view of this outer helical edge), as shown by similar numbers from 0′ to 8′ on M N. From 8′ at right angles to M N erect the line 8′ 8^b equal to 0′ 8′ on the line B C in elevation. Draw a line from 8^b to 0′ in diagram P, and from points 1′,

6′ or 7′ on the line M N erect perpendiculars, cutting the pitch line 8^b 0′ at 1^b, 6^b or 7^b. Any one of these spaces will give the true distance of the spaces along the outer edge line of the spiral F G in elevation.

From this diagram P, the pattern for the vertical ledge for a one-half revolution can be obtained. Simply take the hight from F to *i* in elevation and place it on the two perpendiculars erected from 0′ and 8^b in diagram P, as shown by *f*″ and *f*′ respectively. Draw a line from *f*′ to *f*″, and allow an edge for wiring as shown. Then *f*′ 8^b 0′ *f*″ is the desired pattern.

The approximate pattern for the concave spiral is developed as follows: Take the distance from *d* to *f* in elevation and place it in diagram R on the vertical line from 0 to 0′. Now, with radius equal to 0′ 1^b in diagram P, and 0′ in diagram R as center, describe an arc, which intersect by an arc, struck from 0 as center and 1′ 1″ in diagram H as radius. Now, with 0 1^a in diagram J as radius, and 0 in the pattern R as center, describe an arc, which intersect by another arc, struck from 1^b as center and 0 0′ in R as radius. Trace a line through points thus obtained, then will 0′ 1^b 1^a 0 be the pattern for one part or one-sixteenth of a full revolution shown in plan by 0′ 1′ 1 0.

In the pattern R four of these parts have been joined, thus giving an approximate pattern for a one-fourth revolution of the helical slide. As previously explained, it depends upon the diameter and shape of the conveyor to determine in how many sections the full revolution will be made up. The development obtained in diagram J is also used to obtain the intersecting line D E in elevation, by rolling up K L to an 8-in. semi-circle and placing 8 8^a vertically against the shaft, and scribing a line on the shaft, along 8^a 0 of diagram J. The line then obtained as shown from D E in elevation forms a guide line when hammering the short sections or stamping the one-eighth revolutions. If M N in diagram P is rolled up to a semi-circle (in this case to 3 ft. 8 in. diameter) the slant line 0′ 8^b will show the true edge line, indicated by F G in elevation, after which the outer edge of the conveyor can be trimmed if made by hand. The vertical ledge pattern is first wired, then rolled up in the rollers to the proper diameter, placing the ends 8^b *f*′ or *f*′ 0′ parallel to the lines of the rollers when rolling.

PATTERN FOR CANOPY IN A PARABOLIC REFLECTOR

This is a problem of a canopy having an elliptical base in which dimensions are given. The small end of the canopy is to fit the hole in the side of a parabolic reflector made by the intersection of a 2 1-16 in. circular cutter. To obtain the

pattern for the canopy, the following interesting study of the problem has been made.

In the left half of the elevation of the accompanying illustrations, Fig. 49, the outlines are given of the submitted diagram, that is, the curve A B, the line A C, the position and size of the intersecting circular cutter, marked "profile of cylinder" and the included outline of the canopy. To the original drawing was appended the statement that the base of the canopy is an ellipse $2\frac{3}{8}$x$4\frac{3}{4}$ in. The diagram was carefully drawn to full size, but for convenience it is here reproduced to a scale of two-thirds its size, so that the full length of any dimension can be determined by adding to the same one-half itself.

As the parabolic curve is employed as the profile of reflectors, it is inferred that the curve A B of the diagram is one-half the profile of a concave reflector, and that the purpose of the canopy, which is placed within the reflector, is to carry away the gases or heat of a flame or other source of light placed immediately below it and in the optical focus of the reflector. Under these conditions the axial line A C of the reflector would no doubt, when in use, occupy a horizontal position, in which case the left side of the drawing would then represent the top. For convenience in representation and description the position shown has been taken.

Since the profile of a concave reflector is necessarily the same in all directions from its axis, its surface is such as would be generated by the curve B A by revolving the figure B A C about the line A C as an axis. The volume thus generated would be geometrically termed a solid of revolution. Considered as such it belongs to a class of figures termed conoids, from their somewhat conical shape, which figures have special names according to the character of the curves of their profiles.

The reference to the circular cutter leads one to suppose that the opening in the side of the reflector is made by mechanical means, as by the passing of a milling tool in a straight line across one side, cutting into the reflector to the depth shown by that part of the circle which lies inside the curve A B. In this respect the action of the cutter upon the reflector becomes, geometrically speaking, the intersection of a conoid by a cylinder. The development of the shape of the opening in the conoid, then forms the first requirement of the problem. This having been accomplished the second operation is the construction of a canopy, one end of which shall fit this opening, while the other end is an ellipse of the dimensions given above. In this respect the canopy is simply what, in ordinary pattern work, would be termed a transition piece, in shape somewhat resembling the frustum of a cone the axis of which is at right angles to the axis of the conoid, and the pattern must be developed by the methods of triangulation.

The curve A B—that is, any parabolic curve—may be extended indefinitely, but for the purpose of representation it has been terminated at B, drawing the horizontal line B D, representing a base of the conoid. In constructing a plan of the several parts, first carry lines from the points B and A to intersect the center line of the plan immediately above at B^1 and A^1, and from A^1 as center draw the

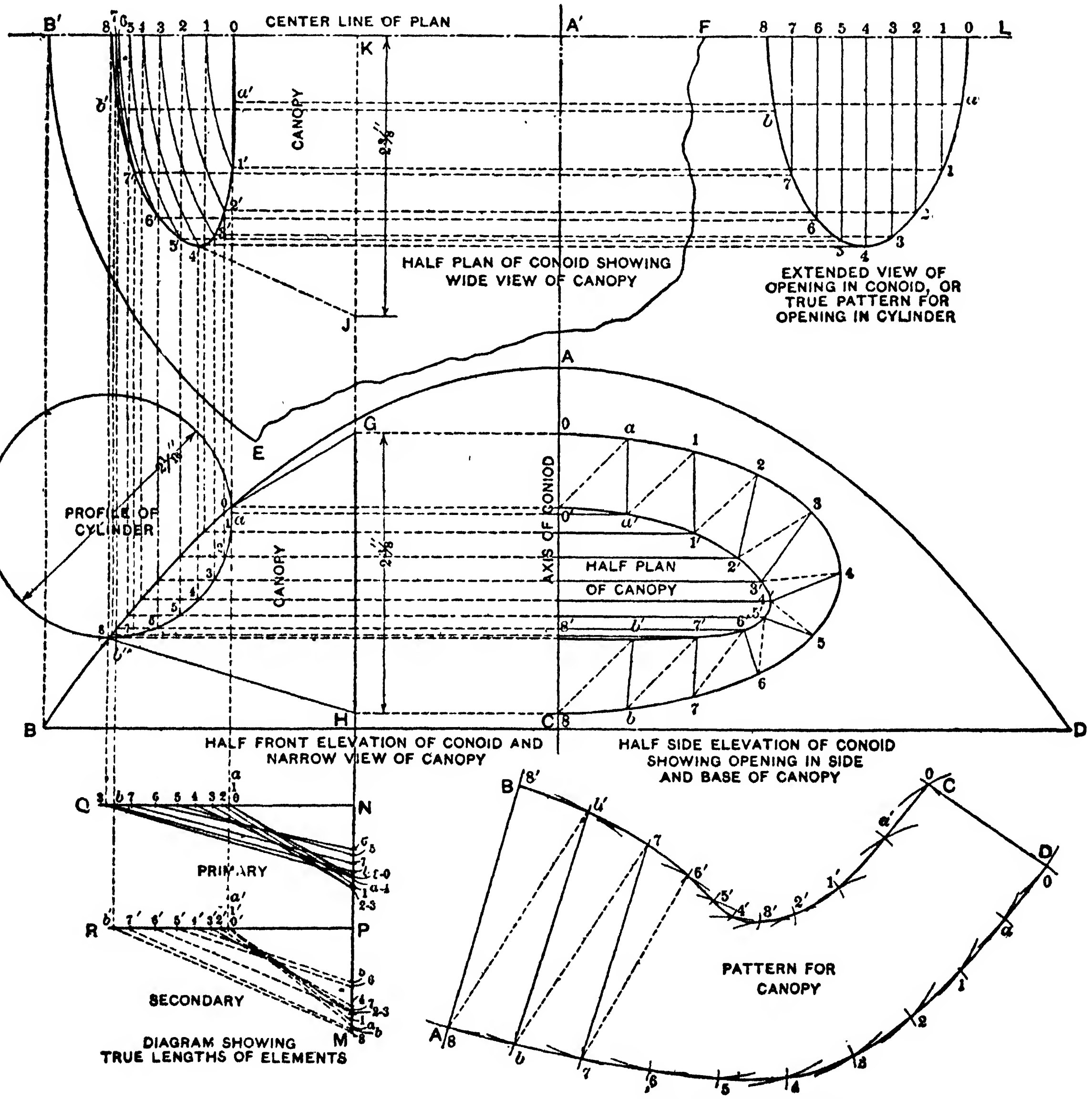


Fig. 49. Pattern for a Canopy in a Parabolic Mirror Involving the Intersection of a Cylinder and a Conoidal Surface

arc B^1 E, which will represent a portion of the circumference of the base, while the broken line E F will include in the half plan a sufficient portion of the conoid to show the hole made by the intersection of the cylinder or cutter.

The first part of the operation will consist in locating the points of penetration. In the revolution of the figure A B C on its axis, A C, previously referred to, it will be seen that each point in the curve A B will describe a circle. Divide that portion of the profile of the cylinder which passes inside the curve A B into any convenient number of equal spaces, as shown by the small figures, 0 to 8. Horizontal lines drawn through each one of these points crossing the elevation and continued to intersect that portion of the curve A B, lying between the points 0 and 8, will represent in the elevation the lines of a certain number of horizontal sections or circular planes, the positions of which in the plan it will be necessary to find. These positions may be determined by projecting lines from each of the intersections on A B, between 0 and 8, to the center line B^1 A^1 of the plan above, as shown by the small figures. These sections may be completed in the plan by describing circles through each one of these points on B^1 A^1 from the point A^1 as center. Portions of the circles only are shown in the plan, which are produced only far enough to receive the necessary intersections.

Project lines upward into the plan to intersect circles of corresponding number. Thus, a line erected from point 1 of the elevation will intersect the circle marked 1 in the plan at point 1'. Lines from points 2, 3, etc., on the profile of the cylinder will intersect circles of corresponding number at 2', 3', etc., of the plan. A line traced through these points of intersection will then give the true plan of the opening made in the side of the conoid by the circular cutter referred to.

The lines 8 H G O of the elevation represent the side or narrow view of the canopy as given in the problem and referred to above. As it was explained that the elliptical base of the canopy is $2\frac{3}{8} \times 4\frac{3}{4}$ in., if desired, in the problem one-half the wide view of the canopy may now be constructed by continuing the line G H into the plan and setting off thereon from the center line one-half the long diameter of the ellipse, $2\frac{3}{8}$ in., as shown by the line K J, drawing a line from J tangent to the curve of the opening just developed in the plan, which it touches near point 4'. This view of the canopy, the outlines of which are shown dotted, being beneath the shell of the reflector as viewed from above, is not absolutely necessary in obtaining the pattern, but will assist the eye in forming an accurate conception of the relative positions of the several parts.

What may be termed a plan of the ellipse is shown at the right in the elevation by the curve designated by the small figures 0 to 8 at the right of the center line A C. It is scarcely necessary to refer to the method of describing this curve, since it is required to be a true ellipse, and may therefore be described by any regular method for drawing an ellipse. For the purpose of completing a view from which

the pattern for the canopy can be obtained, it will be necessary to obtain in connection with this a correct plan or view of the opening in its correct relation to the elliptical base. To do this carry lines from each of the points 1, 2, 3, etc., on the profile of the cylinder to the right, crossing the center line A C and extending them indefinitely. The position of each one of the numbered points in this curve will be derived from the plan of the opening previously obtained above by measuring the distance of each point from the center line B^1 A^1 of the plan and setting off the same distances on horizontal lines of corresponding number, measuring from the center line A C to the right as shown by the points marked 1′, 2′, 3′, etc., in this view.

While the curve B A D, with the base line B D, gives a general elevation of a conoid, that portion of the elevation to the left of the center line A C may for convenience be termed a front elevation of the conoid, and that portion to the right of the center line may represent a side elevation of the same as viewed from the left, or, in other words, as looking from the left through the opening in the side of the conoid, showing what may be termed a plan of the canopy, and is, therefore, a projection in a vertical plane at right angles to that of the view shown at the left.

Having now completed the plan and elevation of the opening in the conoidal surface, the second part of the problem is reached, viz.: developing the pattern for canopy, and the view just completed and termed its plan will be the most suitable view for this purpose. The plan view of the opening in the conoid, as developed from the points upon the profile of the cylinder, contains eight spaces, but as the result of the intersections the space from 0 to 1′ and the space from 7′ to 8′ are very much greater than the other spaces along this. It will, therefore, be advisable to divide each of these spaces into two equal or nearly equal parts. Owing to the peculiar character of this opening neither one of the views thus far obtained shows a full view of both these parts of the opening. That part of the curve from 8′ to 7′ of the plan is more fully shown in the plan of the conoid above the elevation from 8 to 7, and may be there divided into approximately equal spaces by the point *b*′ as shown, and the position on this point *b*′ may be transferred to the plan of the canopy in the same manner as previously described for the other points—that is, by measuring its distance from the line B^1 A^1 and setting the same distance off from line A C on a corresponding line in the plan of the canopy, which has been obtained by first dropping a line from the point *b* in the plan above to cut the profile A B of the elevation, as shown at *b*″, and carried thence into the plan of the canopy at the right. That portion of the curve from 0 to 1′ in the plan of the canopy is fully shown in the plan, and may be divided in that view into equal spaces as shown by the point *a*′.

The result of these operations is to give 10 spaces upon the outline of the opening forming the top of the canopy.

Divide the elliptical base into 10 equal spaces as shown by small figures and the letters *a* and *b*. To avoid confusion in the operations of triangulation it will be advisable to number these points to correspond with those opposite in the plan of the top as shown. The triangulation may then be shown in this plan by first connecting points of like numbers or letters by the solid lines *a*′ *a*, 1′ 1, 2′ 2, etc., as shown. This divides the surface of the canopy into a number of four-sided figures, which figures may be further divided into triangles by simply drawing diagonals, as shown by the dotted lines *a* 0′, 1 *a*′, 2 1′, etc. As is usual in these operations these four-sided figures are irregular in shape, and it is advisable for accuracy's sake to employ the shorter of the two diagonals and, if possible, to maintain the same order or direction throughout the course. In this case the diagonals were drawn from each figure on the ellipse to the next higher figure on the upper outline. This course, it will be seen, when continued beyond the points 6 6′ will necessitate drawing the diagonal the longer way. The order can be changed at this point if necessary, but is apt to cause confusion, and if the difference is not too great it is usually advisable not to reverse the order.

Two further operations are now necessary before the correct lengths of the various measurements indicated on the plan of the canopy can be obtained. First, a correct development of the opening in the side of the conoid (represented by the inner line of the plan of the canopy) must be obtained as a means of obtaining the correct stretchout of the pattern along its upper edge. This is shown in the small diagram at the right of the general plan, and is obtained by setting off on the center line B^1 A^1 of that view extended, as shown toward L, a correct stretchout of that portion of the cylinder indicated by the points 0 to 8, all as shown by the points 0 to 8 in the diagram referred to and designated as an extended view of the opening in the conoid. From each of the points on the line A′ L drop perpendiculars, as shown, and intersect them with lines carried horizontally from each of the points in the previously obtained plan of the opening in the conoid, as shown. The resulting curve 0, *a*, 1, 2, etc., will be the correct stretchout for what may be termed the upper edge of the pattern of the canopy. This would constitute a true pattern for the opening in the side of the cylinder were it necessary to obtain such a pattern.

As a means now of obtaining the correct lengths of the several solid and dotted lines drawn across the plan of the canopy it will be necessary, in the second place, to construct two diagrams, as shown immediately below the canopy at the left of the drawing. For this purpose extend the line G H downward, as shown,

toward M, and at any convenient points, as N and P, draw the lines N Q and P R at right angles, as shown. From each of the points on the profile of the cylinder from 0 to 8 drop lines cutting these two perpendiculars, as shown by the small figures on each and partially indicated by dotted lines. From the point N on the line N M set off the lengths of the several solid lines of the plan of the canopy, as shown by the distances N *a*, N 1, N 2, N 3, etc., as shown by the small figures. By joining points in the line N M with those of corresponding number in the line N Q, the several oblique lines there shown will be the correct lengths of the primary elements. For obtaining the true lengths of the secondary elements set off from the point P on the line P M the lengths of the several dotted lines of the plan, representing the secondary elements in that view, making the distance P *a*, P 1, P 2, etc., equal to the distances *a* 0′, 1 *a*′, 2 1′, etc., of the plan, being careful that the designating figure on P M corresponds with that end of the line which intersects the base of the canopy. In this diagram the points on the line P M must be connected with points on the line P R, correspondingly with the connections made by the dotted lines of the plan, thus *a*′ on P M is connected to point 0 on P R, 1′ on P M is connected with *a*′ on P R, 2′ on P M is connected with 1′ on P R, etc. These lines shown dotted in the drawing will then represent the correct lengths of the secondary elements.

All the means necessary to develop the pattern for the canopy have been obtained, which may be accomplished in the following manner: Upon any convenient line, as A B, set off the distance 8 8 in the diagram of the primary elements, as shown by points 8 8′ in the pattern. From 8 of the pattern as center, with a radius equal to 8 *b*′ of the diagram of secondary elements, describe a small arc near *b*′ of the pattern, which intersect with a small arc drawn from 8′ of the pattern as center, with a radius equal to 8 *b* of the extended view of the opening, thus obtaining the point *b*′ of the pattern. With this point *b*′ as a center, with a radius equal in length to the line *b* *b* of the diagram of primary elements, describe an arc near *b*, which intersect with another arc drawn from 8 of the pattern as a center, with a radius equal to 8 *b* in the plan of the canopy, thus locating the point *b* of the pattern. Continue this operation using the lengths of the secondary elements in connection with the distances upon the extended view of the opening to determine the points on the upper edge of the pattern, and the lengths of the primary elements in connection with the spaces on the base of the canopy to determine the location of the points on the base of the pattern, until the points 0 0 have been reached, all as shown. Curves traced through the points successively obtained, as shown by B C and A D, will give the required pattern.

PATTERNS FOR SPIRAL INSIDE A CONE

To produce the pattern of a spiral on the inside of a cone revolving around a shaft, such as those used on the inside of a dust collector, to settle and draw the dust down to the receiver, proceed as follows :

As the various lines of curvature in the spiral represent various sections through a solid, only an approximately correct pattern can be obtained, the edges of which must be stretched with the stretching hammer to obtain the proper curvature, as shown by the elevation in the accompanying illustration, Fig. 50, similar to the thread of a screw.

The first step is to draw the plan and elevation as follows: Let A 3^v 7^v represent the elevation of the cone, and B C D E the shaft, the plans of both the cone and shaft being shown below. In this case it is assumed that the spiral is to make two revolutions in the vertical hight from 1 to 1 in elevation, although the same principles apply to any number of revolutions in a given hight.

Divide the plan of the cone into any desired number of equal spaces, in this case eight, bearing in mind, however, that the greater number of spaces employed the more nearly accurate will be the pattern. Number the various points in the plan of the cone from 1 to 8, from which points draw radial lines to the center A°, intersecting and dividing the plan of the shaft, also from 1 to 8. As the plan is divided into eight parts and there are to be two revolutions in the elevation, divide the vertical hight 1 1 in elevation into 2×8 or 16 parts, from 1 to 1° to 1, from which draw horizontal lines in the cone and intersect these by vertical lines erected from similar numbers in the plan of the shaft. A line traced through these intersections, from 1^x 1^t to 1^v will show the line of the spiral around the shaft. From the intersections in the plan of the cone, erect vertical lines intersecting the base of the cone in elevation from 1^v to 8^v, from which points radial lines are drawn to the center A, intersecting similar numbered horizontal lines. A line traced through these points of intersections by 1^x, 7^x, 3^x, 1^t, 7^t, 3^t, 1^v will be the line of the spiral around the inside of the cone, making two revolutions. This completes the elevation of the spiral which, however, is not necessary in the development of the pattern and may be omitted in practical work.

The plan of the spiral will be necessary, in the development of the pattern, and is obtained as follows: As the elevation contains 16 spaces, divide the line from 3^a to 3^b in plan into 16 parts, as shown by the small dots, and using A° as center and the distances to the various dots as radii describe circles which intersect the various radial lines in rotation at 1 2 3 4 5 6 7 8 1 2° 3° 4° 5° 6° 7° 8° and 1, through which the spiral curve of the two revolutions are drawn. Draw

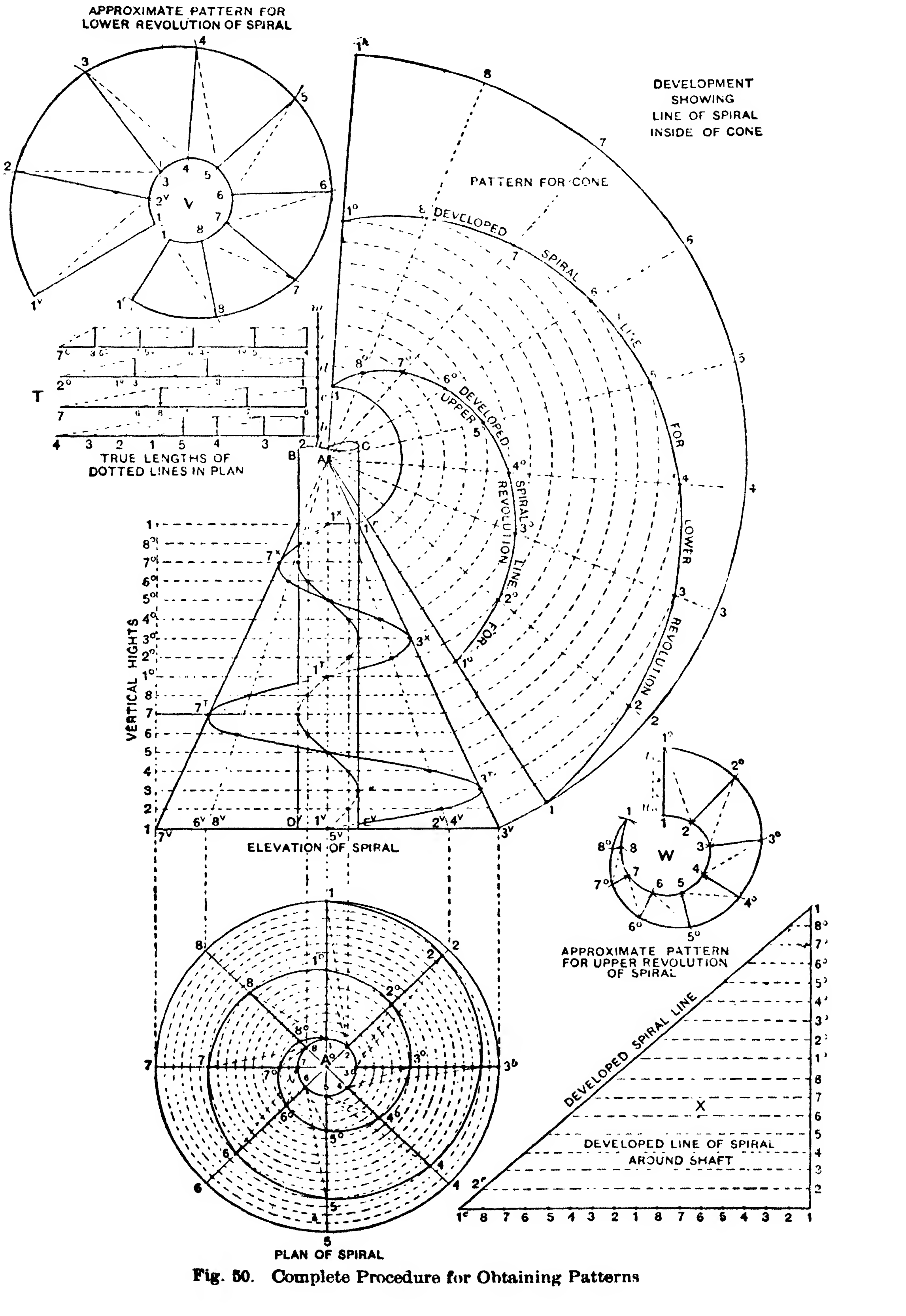


Fig. 50. Complete Procedure for Obtaining Patterns

the solid lines in the plan of the spiral which show their true lengths and carefully note how the dotted lines are drawn for the upper and lower revolution. Taking the space between 7 and 8 as an example, a dotted line is drawn from 8 to 7° for that space in the upper revolution, while a dotted line is drawn from 8 to 7 for the lower revolution, and so on until the last line from 2 to 1 is drawn. As the pattern will be developed by triangulation, then will these dotted lines in plan represent the bases of triangles, which will be constructed in T; the altitude of each will be equal to either one of the vertical spaces in the elevation which are shown by *b*, *c*, *d* and *e* in T. For example, to obtain the true length of the dotted line 7 8 in plan, take this distance and place it from 7 to 8 in T. From 8 erect a vertical line equal in hight to *c* and draw the slant line to 7, which represents the true length. In this manner are all the true lengths found in T as shown by similar numbers. In practice separate diagrams need not be made for each line, but it is done here to make each step clear. The next step is to find the edge line of the spiral around the shaft, as follows: As the spiral makes two revolutions, place double the girth of the shaft in plan on any horizontal line in X, as shown. From 1 erect the vertical line 1 1 equal to the vertical spaces in elevation, and draw a line from 1 to 1^e, which represents the developed spiral line, which could be rolled around the shaft and marked, thus giving the exact line of the spiral around the shaft in elevation. In X all of the horizontal lines have been carried over to the developed spiral line, which is not necessary in practice, one line being sufficient to give the true edge line as indicated from 1^e to 2^e, in developing the pattern.

The edge line of the spiral on the inside of the cone must now be found as follows: Using A in elevation as center, with radii equal to A 3^v and A 1^r, draw the arcs 1 1^h and 1^r 1, respectively. Set off on the outer arc 1 1^h the girth of the plan of the cone, as shown by similar numbers, and draw radial lines to the apex A. Where the various lines, drawn from the vertical hights on 1 1 in elevation, intersect the side of the cone 1^r 3^v, use these points as radii, and with A as center, describe arcs intersecting similar numbered radial lines in the pattern for cone, as shown by similar numbers. A line traced through these points will give the pattern for the cone, as well as the developed line of the spiral on the inside of the cone, for both revolutions. The pattern for the lower revolution of the spiral is obtained as follows: Take the distance of the solid line 1 1 in plan and place it, as shown by 1^v 1 in V. Now set the dividers equal to 1^e 2^e in X, and using 1 in V as center draw the arc 2^v, which intersect by an arc struck from 1^v as center, with radius equal to the slant line of the triangle 1 2

in T. Now set the dividers equal to the distance 1 2 in the developed spiral line for the lower revolution in Y, and with 1^v in V as center, describe the arc 2. Now with radius equal to the true length of the solid line shown by 2 2 in plan, and 2^v in V as center, intersect the arc 2 as shown. Proceed in this manner until the lower revolution in V and the upper revolution in W are developed. In both patterns the measurements along the inner curves are obtained from 1^e 2^e in X; the true lengths of the dotted lines in the patterns are obtained from the hypotenuse of the proper numbered triangle in T; the measurements along the out . curves in the patterns are obtained from the proper numbered developed spiral lines in Y, while the solid lines in the pattern are taken from the proper solid lines in plan. Thus V and W show, respectively, the patterns for the lower and upper revolutions of the spiral. Laps are allowed for joining, as shown by *t u* in W. As before mentioned the outer and inner edges will require stretching to bring out the proper curvatures in the spiral.

CYLINDER INTERSECTING A CONE

The following method of determining the miter line of this problem will be found to be accurate. Let A B C be the elevation of a right cone, which is intersected at right angles to one of its sides by the cylinder D E F G, which is of less diameter than the cone. Beneath the elevation draw a plan of cone and cylinder, as shown. At the outward end of the cylinder in both plan and elevation draw the profiles, which divide into spaces, as shown in Fig. 51. It is evident that the lines D E and G F intersect the cone respectively where these lines intersect the line A C, or at the points D and G. These points have also been numbered 1′ and 5′ to agree with the numbers in the profile. From the other numbers in the profile in the elevation draw lines parallel with the axis of the cylinder, intersecting A C. Continue these lines until they intersect the center line of the cone at the points 2″, 3″, 4″. From these points draw lines parallel with the base of the cone, intersecting the side A B, as shown.

Next locate the points 1′ and 5′ in the plan. This is done by dropping perpendiculars from these points to the line O X. It is necessary to locate the points 2 and 8 in plan, therefore from the point 2′ in elevation drop a line intersecting O X at 2′ in plan. Transfer the distance 2″ 2‴ in elevation from O 2‴ on the line O A. Then, using O 2′ as the semiminor axis and O 2‴ as the semimajor axis, draw the elliptical arc 2‴ 2′ 2^v, which intersect by lines drawn parallel to O X

from the points 2 and 8 in the profile in plan, thus locating the points 2^v 8^v. Locate the points 3^v and 7^v and 4^v and 6^v in the same manner. Connect these

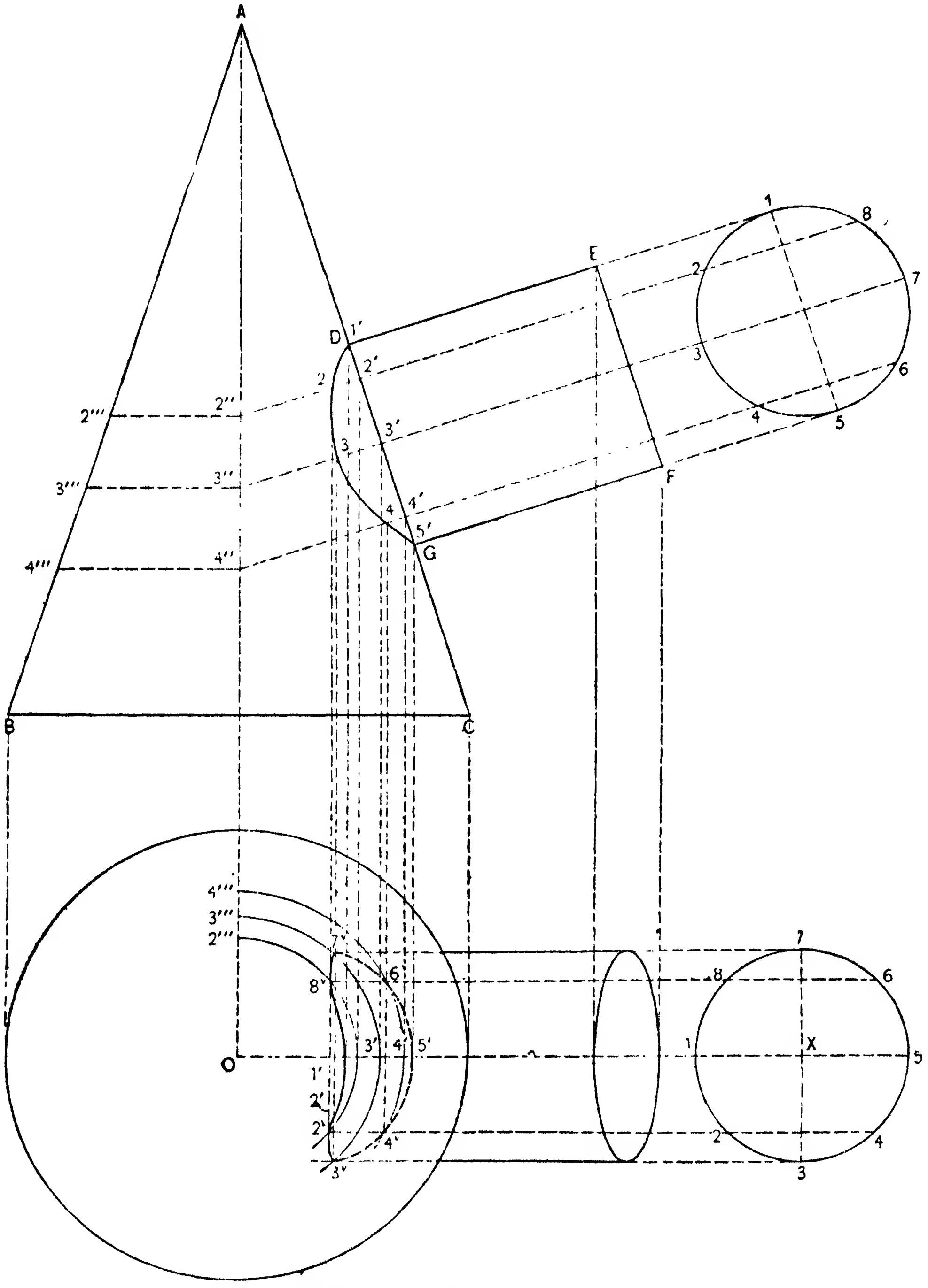


Fig. 51. Plan and Elevation of Cone and Cylinder

points by a curve, thus obtaining the plan of the miter line, as shown. To obtain the location of the points 2^v, 3^v and 4^v in elevation erect lines from these points in

plan until they intersect lines drawn from the points in the profile in elevation bearing similar numbers. At these intersections locate the points, as shown by 2^v, 3^v and 4^v. The locations of the points 8^v, 7^v and 6^v are respectively the same as shown by 2^v, 3^v and 4^v. Draw the miter line $1'$ 3^v $5'$, as shown in elevation. The patterns for the cone and for the cylinder may now be obtained by the usual methods.

A CONE INTERSECTED BY A HORIZONTAL CYLINDER

The first step in making the drawing of the object shown in perspective in Fig. 52 is to draw the front elevation of the right cone, as is shown by A B C in Fig. 53 in which A B is the base of the cone and C D the altitude. Next draw the side elevation, as shown by E F G.

To find the line of the axis of the cylinder, produce A B to I, making B I of the required length. At I erect I R perpendicular to A I, making I R equal to the radius of the cylinder. Through R draw a horizontal line, as shown by 3^2 R 3. It is now desired to find the line of the axis in the side elevation. To do this bisect G E F, and where the line of bisection intersects with R 3 is the projection of the center of the cylinder. From K drop the perpendicular K 5, then with a radius equal to K 5 describe the circle 5 7 2; divide this circle into a number of equal parts, as shown by the small figures, locating another point, x, at the point of tangency between the cone and the cylinder. From these points draw horizontal lines intersecting B C and C D, as shown by similar figures. Continue the line I R until it intersects 1 $1'$ at H, then will 5^2 I H 1^2 represent the front elevation of the cylinder.

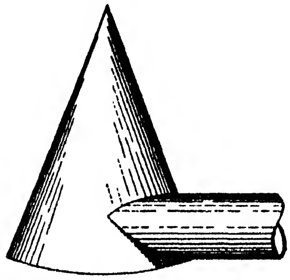


Fig. 52. Perspective View of Cylinder and Cone

To draw the plan directly under D, with O as center and with a radius, O E', equal to D B, draw a circle. From E' on the vertical line O E' lay off E' 5^2, equal to E 5 in the side elevation. Through 5^2 draw a horizontal line to K', on which point with a radius equal to K 5 in the side elevation, draw a circle, as shown, which divide into the same number of parts as was the circle in the side elevation, taking pains to locate the point 1 at 90 degrees to the left of where it is located in the side elevation. Locate the point x at its proper distance between the points 7 and 8, as shown. From these points on the profile draw lines into the plan, as shown. Draw M N directly under H I, then will 3^2 M N 7^2 be the horizontal projection of the cylinder.

To find the miter line between the cone and the cylinder, project onto the horizontal line 0 5′ in plan the points 1′, 2′, *x*′, 3′, 4′ and 5′, in front elevation, as is shown by similar numbers in plan. Through these points, and with O as center, draw arcs, as shown, intersecting the lines bearing similar numbers drawn from the profile K′. At the points where the lines of the same number intersect, locate the points as shown by the numbers 1, 2, 3, 4, 5, 6, 7, *x* and 8. Trace a curve through these lines, as shown, then will this curve be the plan view of the miter line.

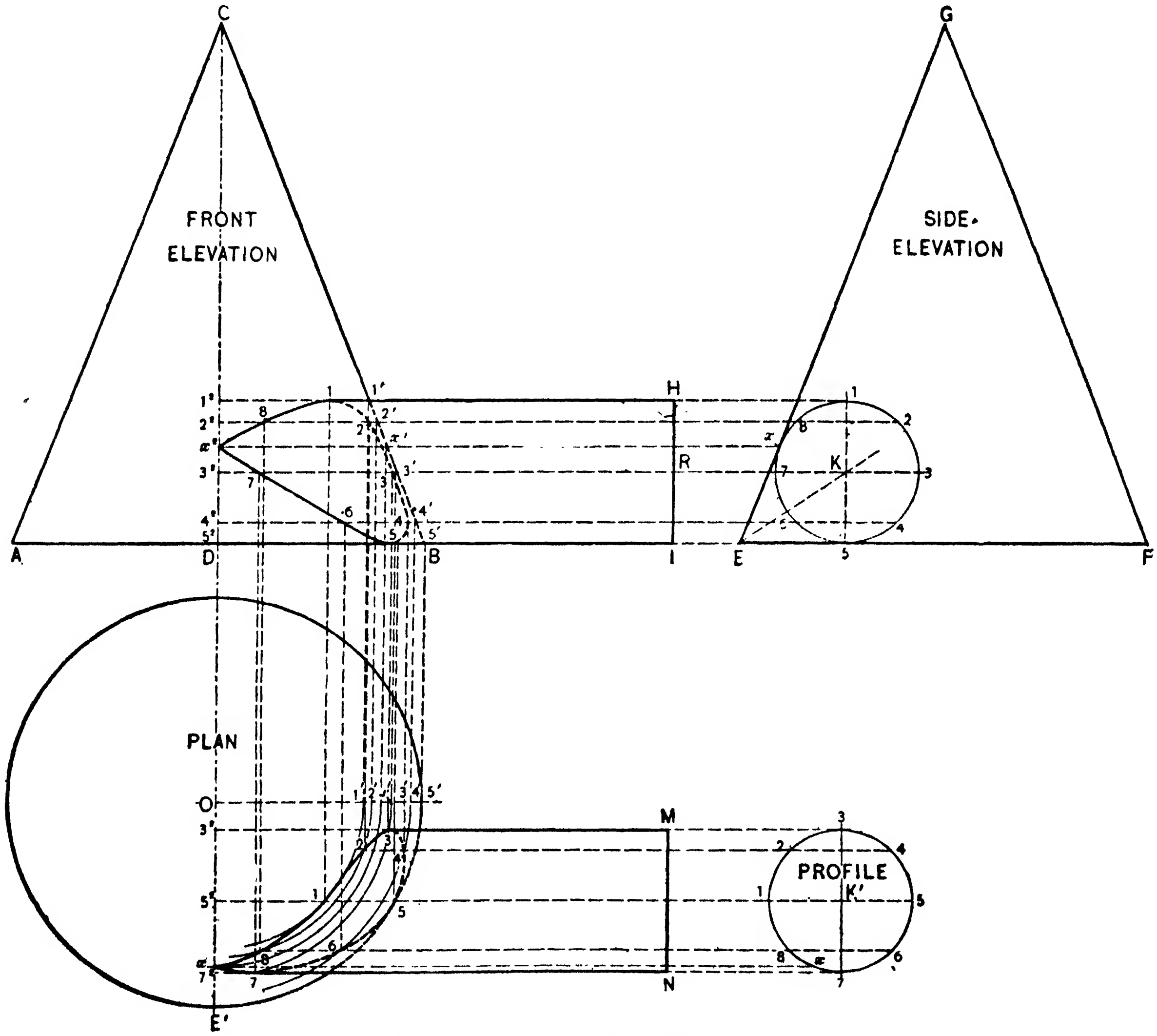


Fig. 53. Determining the Intersecting Lines

To find the elevation of the miter line erect perpendiculars from the point on the miter line just obtained into the elevation. Where these points intersect the horizontal lines drawn from the points in the circle K bearing the same numbers,

locate similarly numbered points as shown by 1, 2, 3, 4, 5, 6, 7, *x*, 2 and 8, tracing a curve through these points, then will this curve show the front elevation on the miter line. To develop the patterns for the cylinder and cone, proceed according to the usual methods.

INTERSECTION OF ELLIPTICAL PIPE AND SCALENE CONE

This is a solution of the intersection of an elliptical pipe and a scalene cone, as in Fig. 54, where A B C is the elevation of the scalene cone, and D E F G its

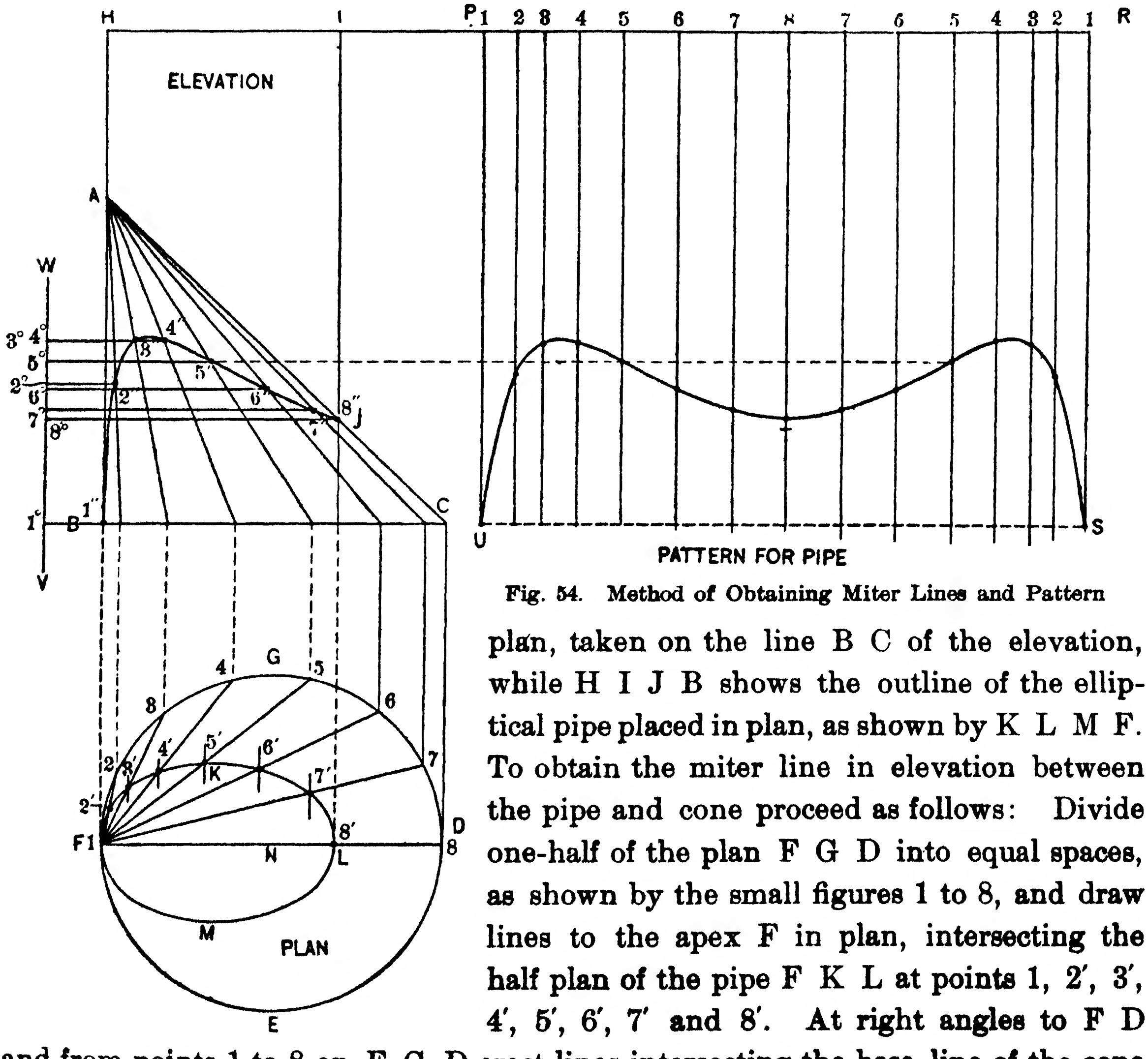


Fig. 54. Method of Obtaining Miter Lines and Pattern

plan, taken on the line B C of the elevation, while H I J B shows the outline of the elliptical pipe placed in plan, as shown by K L M F. To obtain the miter line in elevation between the pipe and cone proceed as follows: Divide one-half of the plan F G D into equal spaces, as shown by the small figures 1 to 8, and draw lines to the apex F in plan, intersecting the half plan of the pipe F K L at points 1, 2′, 3′, 4′, 5′, 6′, 7′ and 8′. At right angles to F D and from points 1 to 8 on F G D erect lines intersecting the base line of the cone in elevation, as shown, from which intersections draw lines to the apex A. Next

intersect these radial lines in elevation with others (not shown) draw from the intersections 1, 2′, 3′, 4′, 4′, 5′, 6′, 7′ and 8′ on F K L in plan at right angles to F D, intersecting similar numbered lines in elevation shown by 1″ to 8″. Trace a line, as shown by B J, through points thus obtained, which will show the miter line or intersection between the scalene cone and elliptical pipe. Parallel to A B draw the line V W, upon which place the various hights of the intersections in the miter line B J from points 1″ to 8″ at right angles to A B, as shown from 1° to 8° on V W. This will be used in the diagram of triangles in Fig. 54.

For the pattern for the elliptical pipe draw any line, as P R, in line H I, upon which place the stretch-out of the elliptical section F K L M in plan, being careful to carry each space separately onto the line P R, as shown from 1 to 8 to 1, because the spaces in F K L M in plan are unequal. At right angles to P R and from the small figures draw lines, as shown, which intersect with others (not shown) drawn at right angles to H B in elevation from similar numbered intersections on the miter line B J. Trace a line through points of intersection thus obtained; then will P R S T U be the pattern for the elliptical pipe.

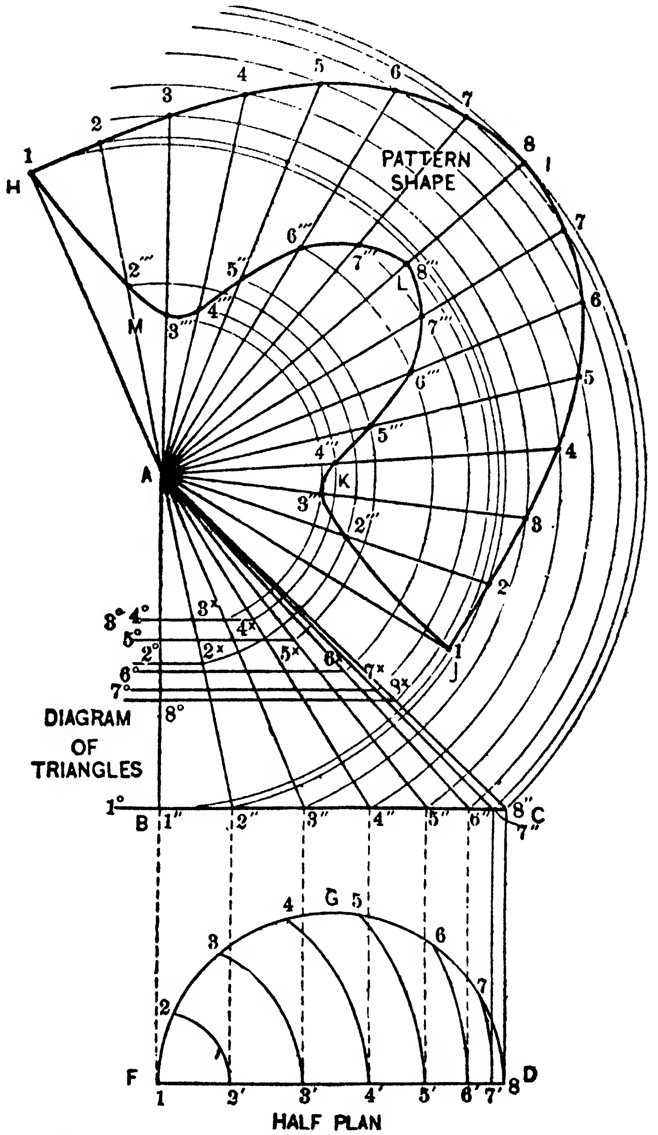


Fig. 55. Method of Obtaining Scalene Cone Pattern

Before obtaining the pattern for the scalene cone it will be necessary to obtain a diagram of triangles from which the pattern is obtained, for which proceed as follows: Let the triangle A B C and the half plan F G D, with the various intersections on same in Fig. 55 be a reproduction of the triangle and half plan having similar letters in Fig. 54. Now, with F as center, Fig. 55, and radii, equal to

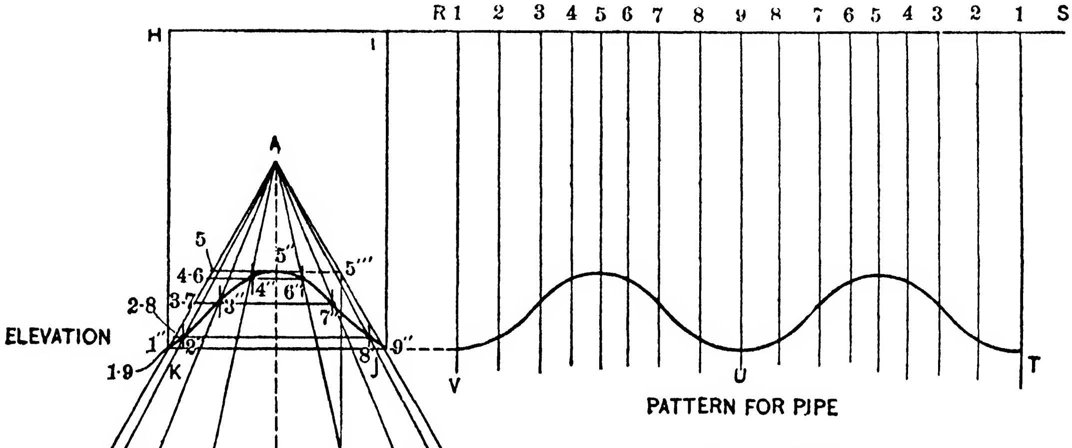
F 2, F 3, F 4, F 5, etc., to F 7, draw arcs intersecting the line F D at points 2′ to 7′. These various lengths represent the base lines of the various triangles which will be constructed by erecting lines at right angles to F D from points 1, 2′, 3′ 4′, 5′, 6′, 7′ and 8, intersecting the base line B C at 1″, 2″, 3″, 4″, 5″, 6″, 7″ and 8″; from these intersections draw lines to the apex A. Take the various hights on V W in elevation, Fig. 54, and place them on the line A B of Fig. 55, placing the point 1° on the point 1″ on the base line B C. Then at right angles to A B and from the various points 1° to 8° draw lines, as shown, intersecting the hypotenuses of triangles having similar numbers, as shown by intersections 2^x to 8^x. With A as center and radii equal to A 1″, A 2″, A 3″, etc., to A 8″, draw arcs, as shown. Now set the dividers equal to the spaces contained in the half plan F G D, and, starting on the arc 1″ at 1, step from one arc to another, or, in other words, starting on the arc 1″ at 1, step to arc 2″, then to 3″, until the point 8 is obtained on arc 8″, which repeat, going backward, until the point 1 on the arc 1″ is obtained. Trace a line, as shown by H I J. Again using A as center and A 2^x, 3^x, 4^x, 5^x, 6^x, 7^x and 8^x as radii, intersect radial lines in pattern drawn from the small figures on H I J to the center A, thus obtaining the intersections 2‴ to 8‴ to 2‴ in pattern. Trace a line, as shown by J K L M H, and H I J K L M H will be the pattern for the scalene cone.

INTERSECTION OF RIGHT CONE AND ELLIPTICAL PIPE

Herein is a solution of a problem based upon the intersection of an elliptical pipe and a right cone, as shown in Fig. 56. Here A B C is the elevation of the cone and D E F G its plan struck from the center P, while H I J K is the outline of the pipe in elevation meeting the cone at J and K, the plan being L M N O. The first step is to obtain the miter line between the cone and pipe. Therefore divide the half plan, F G D, into equal spaces, as indicated by the small figures 1 to 9. From these small figures draw radial lines to the center P, intersecting half of the elliptical pipe L M N at 1′, 2′, 3′, 4′, etc., to 9′. From the intersections 1 to 9 on F G D, and at right angles to F D, draw lines intersecting the base of the cone B C. From these intersections draw lines to the apex A, which intersect with vertical lines (not shown) drawn from intersections having similar numbers on L M N in plan, as shown by 1″, 2″, 3″, 4″, 6″, 7″, 8″ and 9″ in elevation.

To obtain the intersection 5″, use P in plan as center and P O or P 5′ as radius, and strike the arc O 5, intersecting the line F D at 5. At right angles to F D, and from 5, erect the vertical line intersecting the side of the cone A C at 5‴. From 5‴, at right angles to 5‴ 5, draw a line intersecting the radial line 5 in elevation at 5″. Then through the intersection obtained in elevation trace a line, as shown by K J, which will represent the line of joint or miter between the elliptical pipe and cone.

For the pattern for the pipe, draw any line, as R S, in line with H I of the elevation, and upon the line R S place the stretchout of the elliptical pipe L M



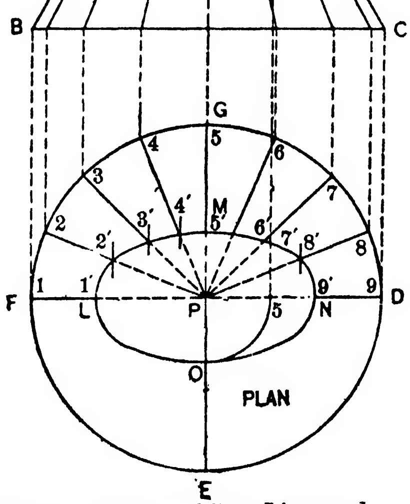


Fig. 56. Obtaining Miter Lines and Pattern for Pipe

N O in plan, being careful to carry each space on L M N separately on R S, as shown by the small figures 1 to 9 to 1. At right angles to R S, and from these figures, draw lines, as shown, which intersect with others (not shown) drawn from intersections having similar numbers on the miter line K J at right angles to A G. A line traced through points thus obtained, as shown by R S T U V, will be the pattern for the elliptical pipe joining the right cone.

For the pattern for the cone proceed as follows: At right angles to A G in elevation, and from the various intersections in the miter line K J, draw lines until they intersect one side of the cone, as A B, as shown by 1 9, 2 8, 3 7, 4 6 and 5. Now, using A B as radius and A in Fig. 57 as center, describe the arc 1 1′, upon which place the stretchout of twice the amount of the half circle in plan,

Fig. 56, as shown from 1 to 9 to 1′ of Fig. 57. From these points draw radial lines to the center A, as shown, and with radii equal to A 1 9, A 2 8, A 3 7, A 4 6, and A 5, and A of Fig. 57 as center, describe arcs intersecting radial lines of similar numbers, as shown. A line traced through the points of intersection

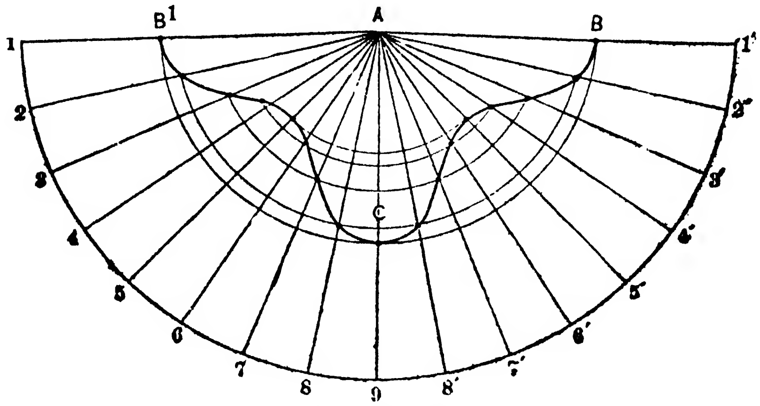


Fig. 57. Obtaining Pattern of Cone

thus obtained, as shown by B C B^1, will be the miter cut joining the elliptical pipe, while 1 B^1 C B 1′ 9 1 will be the pattern shape for the right cone.

PATTERNS FOR INTERSECTING ELLIPTICAL CONES

In Fig. 58 there is presented an interesting problem in intersections. In Fig. 59 is shown an enlarged view, and the method of drawing the plan elevation and miter lines. Let A, B, C, D be the side elevation of the frustum of an oblique cone and E F G H a side view of the frustum of a right elliptical cone. Let O P W S represent the plan view on the lines of base, D C, of the elevation struck from the center V, and K L M N a section of the line G F in elevation, the ellipse being drawn by any convenient method. Extend the lines C B and D A of the elevation until they meet, thus locating the apex J. Divide the plan O P W S into any number of equal spaces as shown by the small figures 8 to 15 and as 15 or W represents the apex of a cone in plan, draw lines from the spaces obtained, O P W S, to 15 or W as shown. At right angles to O W and from the divisions in O P W draw lines upward intersecting the base line D C in elevation at points 8′ to 15′. From these points on the base line P C draw lines to the apex J cutting the line of the upper base A B at points shown from 8″ to 15″. A plan view of the upper base of the frustum A B may be obtained if desired in the following manner: From the intersections 8″ to 15″ and at right angles to D C

draw lines (not shown in diagram) intersecting radial lines of similar number in plan, as shown by the small dots. The line T V U W traced through these points will give the required plan.

Extend the lines G H and F E in elevation until they meet in the apex I which will be directly in line with Q, the center of the ellipse K L M N. Divide one-half of this ellipse into equal spaces as shown by the small figures 1 to 7. Through the small figures and at right angles to K M draw lines intersecting the base line G F as shown from 1′ to 7′. From these points draw lines to the apex I, cutting the radial lines in the oblique cone as shown. The next step will be to obtain sections of the oblique cone on the radial line drawn to I. It should be understood that the sections of the oblique cone need be extended only to the line 10′ 10″ in elevation or 10 W in either side of the plan, as they will then be sufficient to obtain the intersection in plan between the elliptical and oblique cones. If, however, the elliptical cone was wider and longer on H E in elevation, thus cutting deeper into the oblique cone, the section lines in plan could be extended as much as required by the same method. To obtain the lines of these sections and plans proceed as

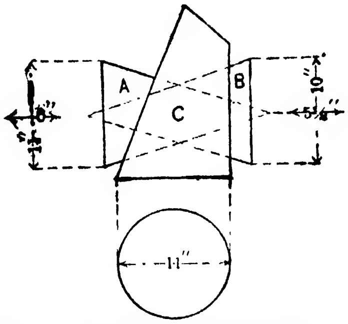


Fig. 58. The Presented Problem

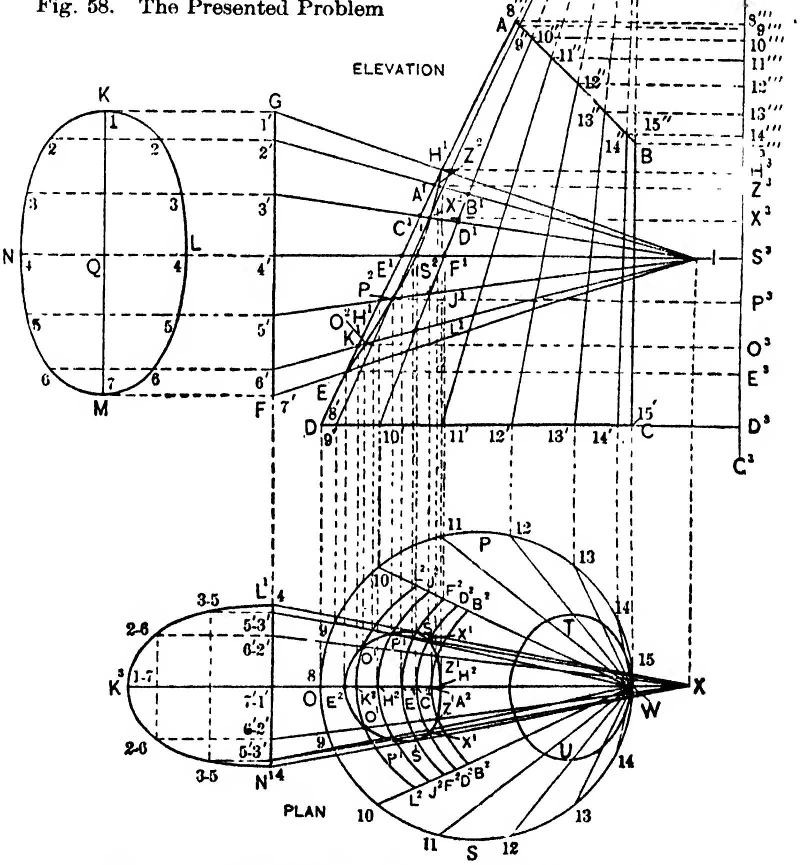


Fig. 59. Procedure for Obtaining Lines of Intersection

follows: As the sides of the elliptical cone G H and F E intersect the side of the oblique cone at H and E, and as the line D A is shown in plan by O V, then at right angles to D C and from the points A^1, C^1, H, H^1 and E^1, E, K^1, drop lines as shown, intersecting O V in plan from E^2 to H^2.

In the same manner from the point where the radial lines 2′ I to 6′ I of the elliptical cone in elevation intersect the radial lines 9′ 9″ and 10′ 10″ of the oblique cone, drop lines intersecting radial lines of similar number in plan, as 10 W and

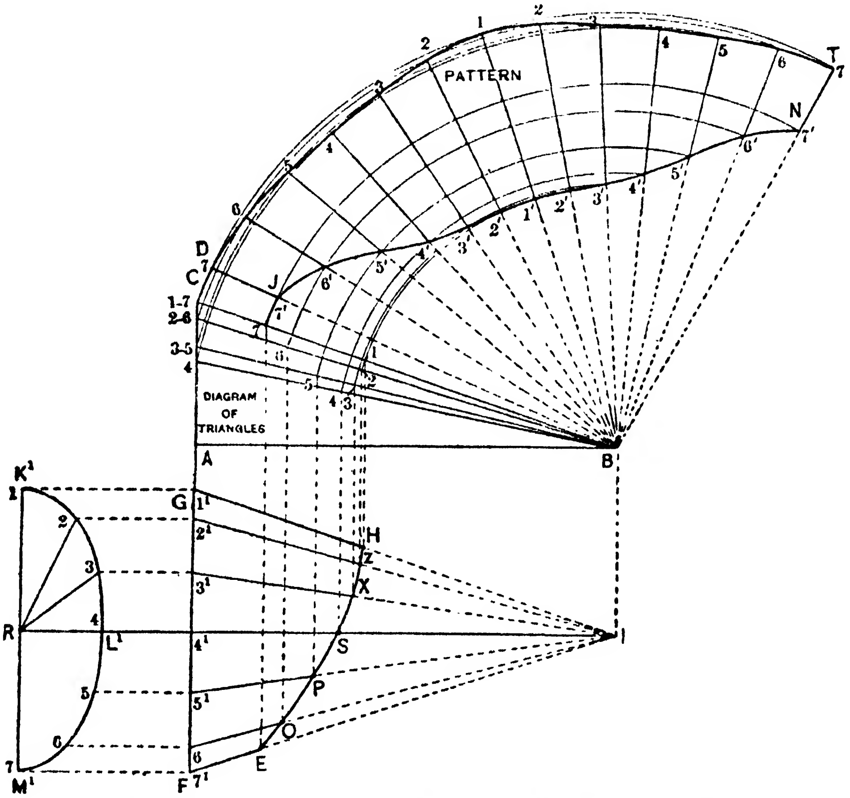


Fig. 60. Procedure for Obtaining Pattern of Right Elliptical Cone

9 W. Trace lines through these intersections as shown; then will the section line L^2 K^2 L^2 represent a plan view of this section K′ L′ of the elevation; also the section lines J^2 H^2 J^2, F^2 E^3 F^2, E^2 C^2 D^2 and B^2 A^2 B^2 will give the plan view of sections taken on the lines J^1 8^1, F^1 E^1, D^1 C^1, B^1, A^1, respectively of the elevation.

Having obtained the section lines and plans the next step is to obtain the intersections of the radial lines of the elliptical cone in plan, so that the miter line between the elliptical and the oblique cone can be obtained in elevation. First obtain this miter line or intersection line in plan as follows: Extend the center

line O W in plan either way as shown by K^3 X. At right angles to D C in elevation from the apex I and from the line G F in elevation drop lines intersecting the center line K^3 X in plan at X and 1′ extending the lines to 1′ indefinitely. Take a tracing of the half ellipse in elevation N K L and transfer to the line L^1 N^1 in plan as shown by N^1 K^3 L^1; care being taken to place the point K^3 on the center line as shown. Now from the divisions on the half ellipse in plan (which correspond in spaces and number to those in elevation) and at right angles to L^1 N^1 draw lines intersecting the base line L^1 N^1 at points 5′ 3′ 6′ 2′ and 7′ 1′. From these intersections draw lines to the apex X as shown. As the section line E^1 F^1 in elevation is taken on the radial line 4′ I, then must the corresponding section, F^2 E^2 F^2, in plan be cut by the corresponding radial lines 4 X at the points S^1 S^1.

As the section lines A^1 B^1, C^1 D^1, H^1 J^1 and K^1 L^1 in elevation are taken on the radial lines 2′ I, 3′ I, 5′ I, and 6′ I respectively, then must the section lines of similar letters in plan B^2 A^2 B^2, D^2 C^2 D^2 J^2 H^2 J^2 and L^2 K^2 L^2 be cut by the radial lines 2′ X, 3′ X, 5′ X, 6′ X, on either side of the center lines K^1 X, as shown by the points Z^1, X^1, P^1 and O^1, the points E^2 and H^2 having been previously obtained. Trace a line through these points, when E^2 O^1 P^1 S^1 X^1 Z^1 H^2 will be a half plan of the miter line. The opposite half can be obtained by tracing if desired.

Having obtained this miter line in plan, the next step is to develop the same in elevation. At right angles to K^3 X in plan and from the intersections O^1, P^1, etc. carry lines upward, intersecting corresponding section lines K^1 L^1, H^1 J^1, etc. in elevation as shown by O^2, P^2, S^2, X^2 and Z^2. A line if traced through the points will constitute the miter line in elevation showing the intersection between the elliptical and the oblique cones.

In Fig. 60, E F G H I is a reproduction of E F G H I of Fig. 59 and is carried forward so as to avoid a complication of lines in the development of the pattern for the right elliptical cone. In the Fig. 60, H Z X S P O E is a reproduction of H Z^2 X^2 S^2 P^2 O^2 E of Fig. 59, as is the half elliptical section with the divisions on same a reproduction from Fig. 60. As the apex of a right elliptical cone is directly central over its base, then from the divisions 1, 2, 3 and 4 in the half ellipse Fig. 60, draw lines to the centre R. These lines will then represent the bases of the triangles to be constructed as follows: Parallel to R I draw any line, as A B. At right angles to R I and from points 4′ and I draw lines intersecting A B at A and B. At right angles to A B draw the line A C. Take distances R I, R 2, R 3 and R 4 setting them off on the line A C, measuring in every instance from point A, as shown by the same figures. As the distances

R 5, R 6, and R 7 are equal to R 3, R 2, and R 1, then add these figures as shown on the line A C. From the points on A C draw lines to the apex B; then will A B C represent the diagram of triangles used in the development of the plan. At right angles of R 1 and from the intersections H, Z, X, S, P, O and E on the radial lines draw lines intersecting those of similar numbers in the diagram of triangles as shown by the points 1 to 7.

For the pattern proceed as follows: With B in the diagram of triangles as center and with radii B 7, B 6, B 5 and B 4 on the base line A C draw arcs, as shown. In this case the seam is placed at the point 7 at the bottom of the cone. Starting at the point 7 on the arc 7 7, take the distance in the dividers equal to the spaces into which the half ellipse K^1 L^1 M^1 has been divided and step from one arc to another placing the division 6 of the plan on the arc 6 5 of the plan on the arc 5, until all of the divisions necessary to complete the full pattern are obtained. A line traced through the points just obtained as shown from 7 to 7 will be the outline of the base of the pattern. For that portion of the pattern adjoining the

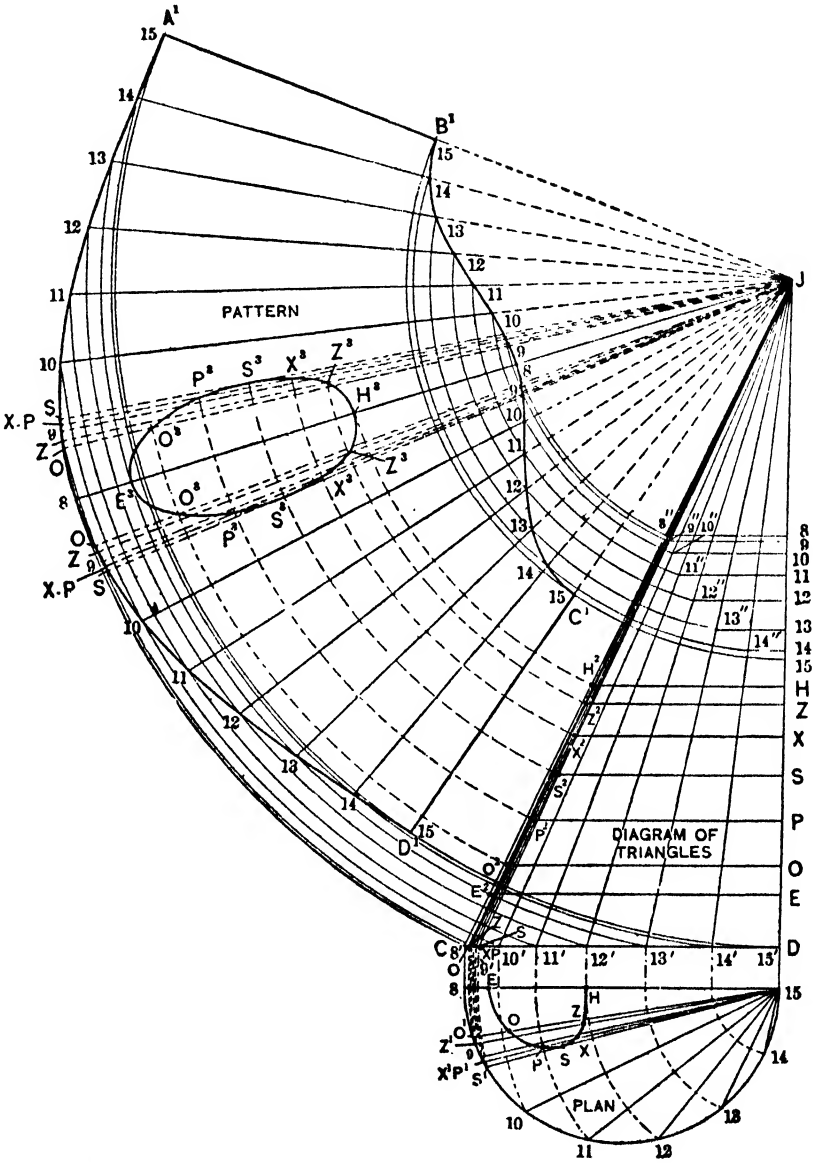


Fig. 61. Procedure for Obtaining Pattern for Oblique Cone

oblique cone draw lines from the intersections on the pattern lines 7 7 to the apex B, intersecting arcs of similar numbers struck from the center B, with radii equal to B 1, B 2, B 3, etc. in the diagram of triangles, as shown from 7′ to 7′ of the pattern. Then will D T N J be the pattern for the right elliptical cone to intersect the oblique cone.

In Fig. 61 J D C is a reproduction of J C D of Fig. 59. The half plan 8 12 15 in Fig. 61 is also a reproduction of the lower half plan of Fig 59, as is the miter line H Z X S P O E in Fig. 61 a reproduction of the lower half of the miter line in plan in Fig. 59. To obtain the diagram of triangle with which to develop the pattern proceed as follows: With 15 in plan as the apex or center, and with radii 15 14, 15 13, 15 12, etc. describe arcs intersecting the center line 8 15, as shown. From the intersections thus obtained and at right angles to 8 15 in plan, erect lines intersecting the base lines as C D at 8′, 9′, 10′, etc. From the various intersections on the line C D draw lines to the apex J: then will these lines represent the hypotenuses of the triangles, bases of which are shown by the straight lines of similar numbers in plan. Parallel to J C in Fig. 59 draw the line J^2 C^3. At right angles to J^2 C^3 and from the intersections 8″ to 15″ on the line A B of the oblique cone draw lines intersecting the line J^2 C^3 from 8‴ to 15‴, as shown. In like manner from the intersections on the miter line H S^1 E and from the points J and C^1 draw horizontal lines cutting the line J^2 C^3 at J^2, H^3, Z^3, X^3, S^3, P^3, O^3, E^3 and C^3. Transfer the points from the line J^2 D^3 to the line J D of Fig. 61. At right angles to J D, and from the small figures on same, draw lines intersecting the hypotenuses of similar figures, as shown by 8″ to 14″ of Fig. 61.

For the pattern for the oblique cones proceed as follows: With J in the diagram of triangles as center and radii equal to J 8′, J 9′, J 10′, etc. on the line C D draw arcs indefinitely, as shown. In this case assume that the seam will come at the point 15 in plan. Take the distance in the dividers equal to the spaces into which the plan is divided, and commencing on the arc 15 15 in pattern step from one arc to another, placing the division 14 of the plan on the arc 14 13 of the plan on the arc 13, until all of the divisions necessary to complete the full pattern are obtained. Through the points thus obtained trace a line, as shown, from 15 to 15, which will be the lower pattern cut. For the upper pattern cut, first draw lines from the intersection on the base line of the pattern 15 to 15 toward the apex J, intersecting arcs of similar numbers struck from the center J with radii equal to J 8″, J 9″ or J 10″, etc. in the diagram of triangle, as shown by the intersection from C^1 to B^1. A line traced through these intersections will give the upper cut of the pattern. Then A^1 B^1 C^1 D^1 will be the pattern for the frustum of the oblique cone.

For the shape of the opening to be cut into the oblique cone to admit the elliptical cone proceed as follows: From the center point 15, draw lines through the intersections in the miter lines in plan H S E, continuing them until they intersect the plan of the base at Z^1, X^1, S^1, P^1 and O^1. With 15 in plan as centre and with radii equal to 15 O^1, 15 Z^1, etc. describe arcs intersecting the line 15 8, as shown. At right angles to 15 8 and from intersections just obtained erect lines intersecting the base line C D at O, Z, X, P and S. From these intersections draw lines toward the apex J, to intersect the horizontal lines with similar letters drawn from the points on the J D, as indicated by the dots between H^2 and E^2. Take the distance 8 to O^1 in plan in the dividers and placing one point at 8 in the lower line of pattern, set off the distance on either side toward 9, as shown by O O. In the same manner set off the distance from A to Z^1 of the plan on either side of the point 8 in pattern, as shown by Z Z; finally take the distances 9 to S^1 and 9 to X^1 P^1 in plan and set them off in pattern, measuring on either side from the point 9, as shown by S, X P, on either side of the pattern. From the points S, X P, Z, O, draw lines toward the apex J, which intersect with the arcs of similar letters struck with the apex J as centre, from H^2, Z^2, X^2, S^2, P^2, O^2 and E^2 in the diagram of triangles, as shown in the pattern by H^3, Z^3, X^3, S^3, P^3, O^3 and E^3. A line traced through these points will give the shape of the opening to be cut out of the oblique cone to admit the elliptical cone.

ENVELOPE OF SCALENE CONE WITH FLAT SIDE AND TOP

The subjoined paragraphs tell how to describe the pattern for the frustum of a cone which is flat on one side, the top opening to be perpendicular to the flat side, as shown in Fig. 62, in which A B C D shows the side elevation of the cone, E F G in plan being the section on D C in elevation and struck from the center H, while I J K L is the plan on A B in elevation and is struck from the center M. E G in plan shows the flat side, on the line D A in elevation.

With H in plan as center, complete the full circle of the base, as shown by G N E, and draw the center line in plan N F. Likewise in elevation extend the base line C D, as shown by C O, which intersect with a line drawn from N in plan at right angles to F N, thus obtaining the point O in elevation. From O draw a line to A, extending it indefinitely, as shown by O P. In similar manner extend the line C B until it intersects O P at P. At right angles to N F in plan and from the center H draw a line intersecting the base O C in elevation at R. In similar

manner from M, the center of the circle of the top I J K L in plan, erect a line at right angles to N F, intersecting the top line A B in elevation at S. Draw a line through R and S, which must meet the apex P, as shown, thus making P O C a scalene cone. From P at right angles to O C drop a line intersecting the line N F in plan at T, which is the apex in plan of the scalene cone. Now divide the half plan N 4 F into equal spaces, as shown by the small figures 1 to 7; from these small figures draw lines to the apex T in plan, the radial line 6 T intersecting the flat side E G in plan at 6‴. From 6 erect the vertical line intersecting the base line C O in elevation at 6′, from which draw a line to the apex P, intersecting the side A D at 6″.

For convenience, when getting out the pattern for the flat side establish any point, as *a*, on the line A D in elevation. From *a* draw a line to the apex P, extending it downward until it intersects the base line O C at *a*′. From *a*′ at right angles to O C drop a line, intersecting the circle at *a*″, from which draw a line to the apex T in plan, intersecting the flat side E G at *a*‴. All of these points represent the basis of all measurements required for the patterns.

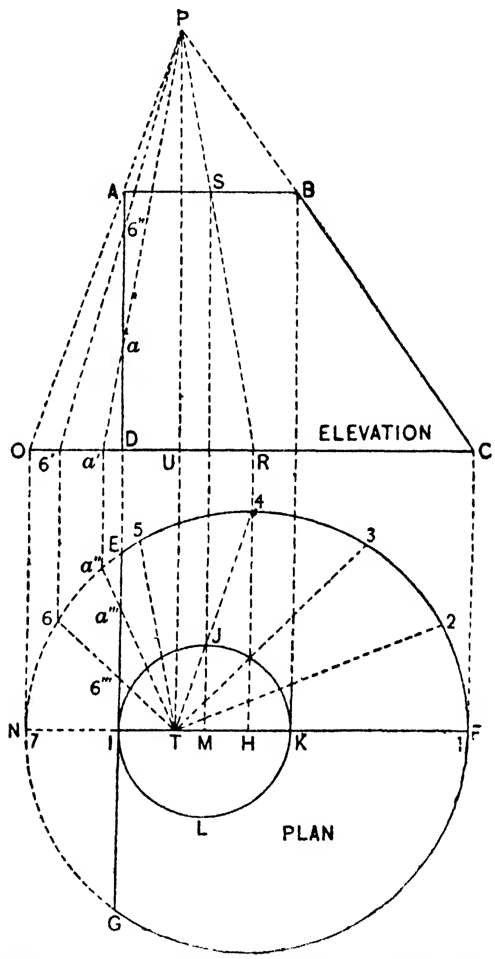


Fig. 62. Completing the Problem as Presented

Before obtaining the pattern for the scalene cone, first construct the diagram of triangles shown in Fig. 63, in which 1 T 7 4 is a reproduction of 1 T 7 4 reversed in Fig. 62. Take the various divisions 6 *a*″ E 5 4 3 2 1 and place them as shown by 6 *a* E 5 4 3 2 1 in Fig. 63. From these points draw lines to the apex T in plan. Using T as center and radii equal to T 7, T 6, T *a*, T E, T 5, T 4, T 3 and T 2, draw semicircles, as shown, intersecting the center line 1 7, as shown. From these intersections and at right angles to 7 1 draw lines intersecting any horizontal line, D 1, at points D, 7, 6, *a*, E, 5, 4, 3, 2 and 1. Extend the line T D indefinitely to P, as shown. Take the distance from U to P in Fig. 62 and place it as shown from D to P in Fig. 63. Then from the various intersections on D 1 draw lines to the apex P, as shown. Take the various hights

in Fig. 62 from D to *a* to 6″ to A and place them in Fig. 63 on the line D P, as shown from D to *a* to 6 to A. At right angles to D P and from A draw the line A B, which represents the top of the opening.

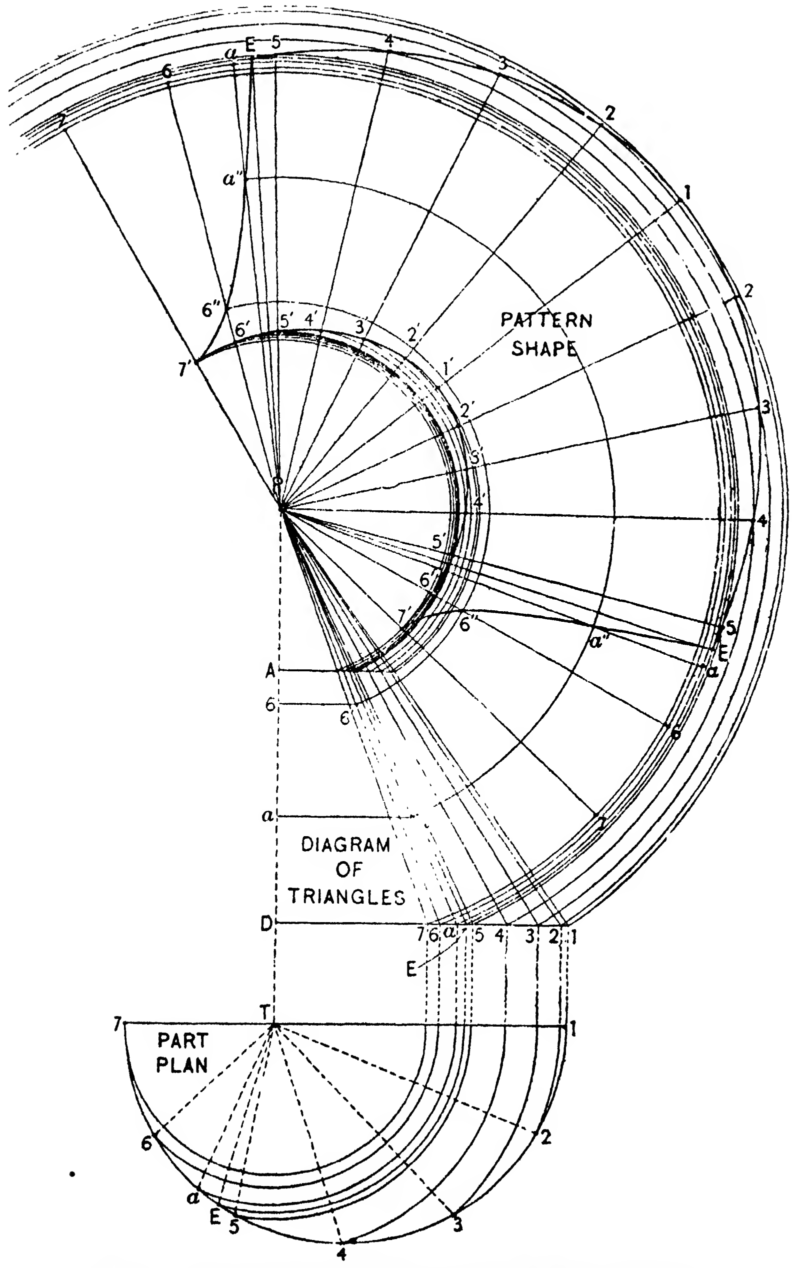


Fig. 63. Obtaining the Diagram of Triangles and Pattern

In similar manner at right angles to D P and from the intersections 6 and *a* draw lines intersecting hypotenuses having similar numbers, as shown by the intersections 6′ and *a*′ respectively. Then will these lines represent the diagram of triangles used in the development of the patterns. For the pattern shape use P as center, and with radii equal to P 7, P 6, *a*, E, 5, 4, 3, 2 and 1, strike arcs indefinitely, as shown. Set the dividers equal to the divisions into which the plan is divided, and starting from the arc 7 step to the arc 6, then to the arc 5, then to 4, 3, 2 and 1, and reverse the operation and step to arcs 2, 3, 4, 5, 6 and 7, as shown. From these points draw lines to the apex P. Next set the dividers equal to the distance 6 *a* in plan, and step from the arc 6 in the pattern to the arc *a*, as shown by *a* on each side. In similar manner take the distance from *a* to E

in plan, and step from arc *a* to arc E in pattern on either side. From the points *a* E and E *a* in the pattern draw lines to the apex P. Now with radii equal to P 6 and P *a'* draw arcs intersecting the radial lines in the pattern drawn from points *a* *a* and 6 6, thus obtaining the intersections *a''* *a''* and 6'' 6''. Finally, with P as center and radii equal to the various numbers 1 to 7 on A B (not shown), draw arcs intersecting radial lines having similar numbers, as shown, thus obtaining the points 7' to 1' to 7'. Trace a line through points thus obtained; then will 7' 6'' *a''* E 1 E *a''* 6'' 7' 1' 7' be the pattern shape for the scalene cone.

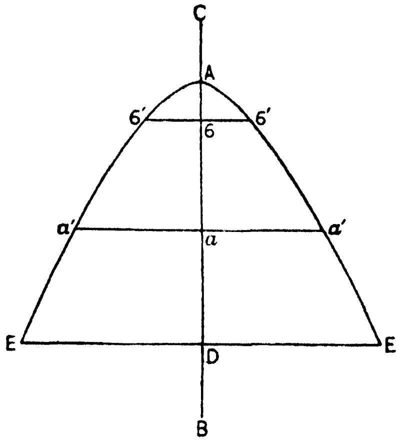


Fig. 64. Pattern of the Vertical Side

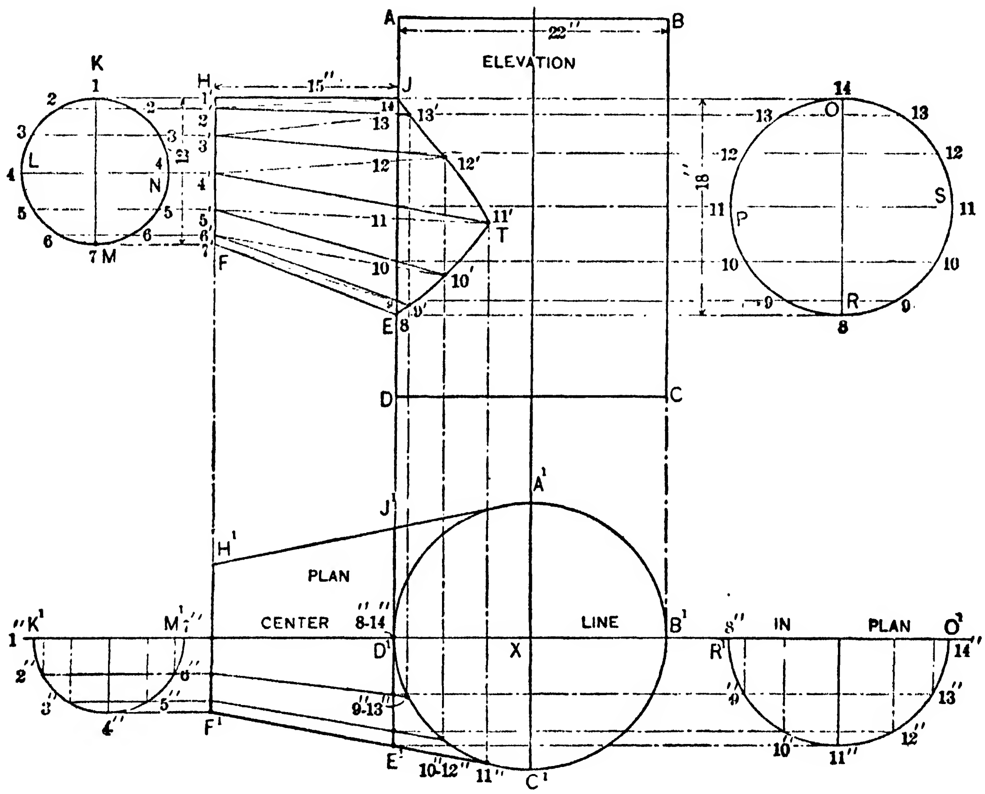
For the pattern for the flat side draw any line, as B C in Fig. 64, upon which place the distances A 6 *a* D, equal to A 6'' *a* D in elevation in Fig. 62. At right angles to B C in Fig. 64 and through the points 6 *a* and D draw lines, as shown. Now, measuring in each instance from the line N F in plan in Fig. 62, take the distances to points 6''', *a'''* and E and place them in Fig. 64 on lines having similar letters and figures, measuring in every instance from the line B C on either side, thus obtaining the intersections 6' 6', *a'* *a'* and E E. A line traced through points thus obtained, as shown by E A E, will be the pattern for the vertical side of the cone.

INTERSECTION OF SCALENE CONE AND CYLINDER

The procedure for obtaining the miter between a scalene cone and a 22 inch cylinder, also the patterns, a sketch of which is shown in Fig. 65 is as follows: Here A B C D represents the 22 inch cylinder and E F H J the scalene cone, the intersection between the cone and cylinder being shown by J T E. The diameter of the cone on the line H F which is shown by K L M N is 12 inches and O P R S shows the diameter of the cone on the line J E which is 18 inches, the length of the horizontal arm H J being 15 inches. Draw the plan of the article, placing it under the elevation in its proper position, as shown by the dotted lines, making A^1 B^1 C^1 D^1 the plan of the cylinder. Through the center point X of the circle in plan draw the center lines K^1 O^1, as shown. On either side of the center line in plan, in their proper positions, as shown by the dotted lines locate

H^1 F^1 equal to 12 inches and J^1 E^1 equal to 18 inches. Draw lines from H^1 to J^1 and F^1 to E^1, extending them until they intersect the 22 inch pipe, as shown. Then will H^1 B^1 represent the plan of the scalene cone and cylinder corresponding to the elevation.

The first step is to obtain the miter line J T E in elevation, for which proceed as follows: Divide the profile K L M N into equal spaces, as shown by the small figures 1, 2, 3, 4, etc. At right angles to K M and through the small figures draw lines intersecting the line H F at 1′, 2′, 3′, etc. as shown. In the



ig. 65. Obtaining the Miter Lines

same manner divide the profile O P R S into the same number of equal spaces as in K L M N, as shown by small figures 8 to 14. At right angles to O R and through the small figures, draw lines intersecting line J E as shown from 8 to 14. Now draw solid lines from 2′ to 13′, 3′ to 12′, 4′ to 11′, 5′ to 10′, 6′ to 9′, extending the lines indefinitely into the cylinder. Take a tracing of the profile K 4 M in elevation and place it as shown by K^1, 4″ M^1, in plan, placing the line K^1 M^1 upon the center line in plan, as shown. In the same manner take a tracing of the profile O 11 R in elevation and place it as shown by O^1 11″ R^1 in plan, placing

the line O^1 R^1 upon the center line in plan. Parallel to K^1 M^1 and through the small figures 2″, 3″, etc. in the half profile draw lines intersecting the line H^1 F^1 as shown. In the same manner, parallel to R^1 O^1 and through the small figures 9″, 10″, 11″, etc., in the half profile draw lines intersecting the lines J^1 E^1 as shown. From the various intersections on the line H^1 F^1 draw lines through the points on J^1 E^1 as shown, continuing them until they intersect the quarter circle D^1 C^1 at 8″ 14″, 9″ 13″ 10″ 12″ and 11″. At right angles to the center line in plan and from the

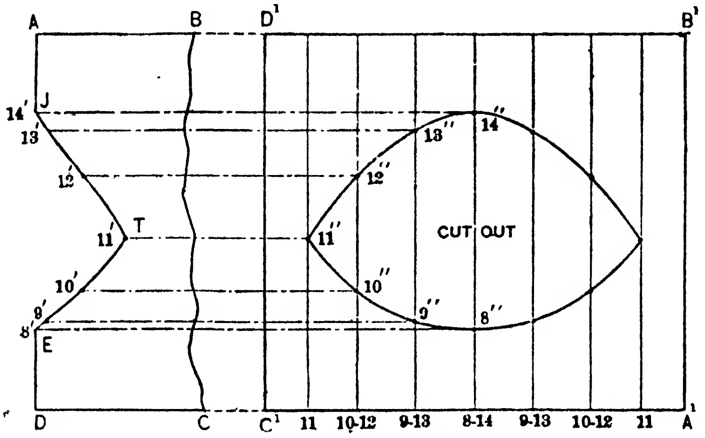


Fig. 66. Pattern of Opening in Cylinder

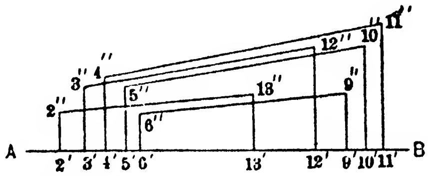


Fig. 67. Diagram of Solid Line Triangles

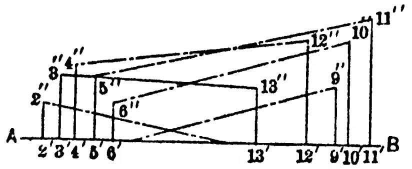


Fig. 68. Diagram of Dotted Line Triangles

intersections on the quarter circle D^1 C^1 carry lines upward intersecting those of similar numbers previously extended into the cylinder, as shown by the points 14′, 13′, 12′, 11′, 10′, 9′ and 8′. A line traced through these points, as shown by J T E will represent the miter line between the scalene cone and cylinder.

The next step is to obtain the opening to be cut into the cylinder. In Fig. 66 let A B C D E J and with the miter line and the various intersections on it be a reproduction, partly broken, of A B C D E J of Fig. 65. On D E of Fig. 66 extended, C^1 A^1, place the stretchout of the half circle in plan, Fig. 65 as shown by the small figures. Now at right angles to C^1 A^1 and through the small figures draw lines, which intersect with those of similar numbers drawn at right angles to A D from the points on the miter line J T E as shown. A line traced through these points from 8″ to 14″ will be the opening to be cut into the cylinder.

The pattern for the scalene cone will be developed by triangulations, and diagrams of sections will be required. Connect points in H F, Fig. 65, with points on the miter line by dotted lines, as shown from 2′ to 14, 3′ to 13′, 4′ to 12′, etc. Draw any horizontal line, as A B in Fig. 67, upon which the various lengths of the solid lines in scalene cone in elevation Fig. 65, as shown by lines of similar

numbers A B of Fig. 67: At right angles to A B and from the small figures draw lines, making them equal in hight to vertical lines of similar numbers in the half profile K^1 4″ M^1 and the quarter circle X D^1 C^1 in plan, Fig. 65. From the points thus obtained in Fig. 67 draw slant lines as shown. For example, take the length of the line 4′ 11′ in elevation Fig. 65, and place it as shown by 4′ 11′ on the line A B of Fig. 67. At right angles to A B draw perpendicular lines 4′ 4″ and 11′ 11″ equal in hight, when measuring from the center line in plan of Fig. 65, to 4″ in the profile K^1 M^1 and 11″ in the quarter circle X D^1 C^1. Now draw a line from 4″ to 11″ in Fig. 67, which will be the actual distance on the finished article on the line 4′ 11″ in elevation Fig. 65. Proceed in the same manner for sections on dotted lines. Draw any line in Fig. 68, as A B, upon which place the lengths of the dotted lines in the scalene cone in elevation, Fig. 65, as shown by lines of similar numbers on A B in Fig. 68. At right angles to A B and from the small figures draw lines, making them equal in hight to vertical lines of similar numbers in half profile K^1 4″ M^1 and the quarter circle X D^1 C^1 in plan Fig 65. From the points thus obtained in Fig. 68 draw slant lines as shown. For example, take the length of the line 5′ 11′ in elevation, Fig. 65, and place it as shown by 5′ 11′ on the line A B of Fig. 68. At right angles to A B draw vertical lines 5′ 5″ and 11′ 11″, equal in hight, when measuring from the center line in plan, Fig. 65 to 5″ in the profile K^1 M^1 and to 11″ in the quarter circle X D^1 C^1. Draw a line from 5″ to 11″ in Fig. 68 which will be the actual distance on the finished article on the dotted line 5′ 11′ in elevation Fig. 65.

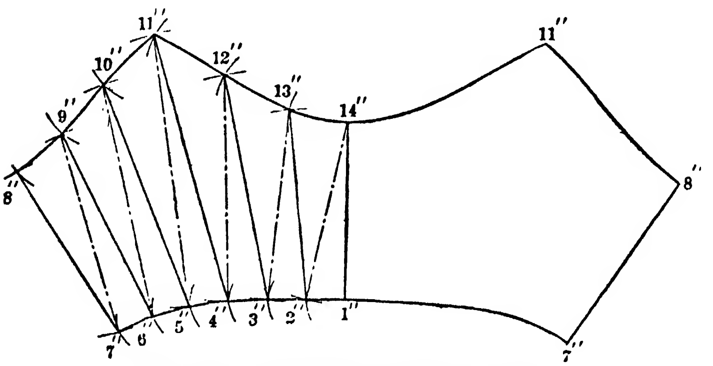


Fig. 69. Full Pattern of Scalene Cone

These are now the diagrams of sections in Fig. 67 and 68, the half profile of the narrow end of the scalene cone K^1 M^1 in plan Fig. 65 and the various divisions in the pattern in Fig. 66, from which to obtain measurements for developing the pattern for the scalene cone, for which proceed as follows: Draw any vertical line, 1″ 14″ of Fig. 69, equal to 1′ 14 or H J in elevation, Fig. 65. With 1″ 2″ in the half profile K^1 M^1 in plan as radius, and 1″ of Fig. 69 as center, describe the arc 2‴. Then, with 14 2″ of Fig. 68 as radius and 14″ of Fig. 69 as center, intersect the arc previously described at 2″. Now with 14″ as center, and 14″, 13″ of the pattern,

Fig. 66, as radius, describe the arc 13″ in Fig. 69. Then with 2″ as center and 2″ 13″ of Fig. 67 as radius, describe an arc intersecting the previous arc 13″ of Fig. 69. Proceed in this manner, using alternately first the spaces in the half profile K^1 M^1 in plan Fig. 65, then the lengths of the dotted lines in Fig. 68, then the spaces in the pattern of Fig 66 and the lengths of the solid slant lines in Fig. 67, until the last line 7″ 8″ of Fig. 69 is obtained equal in length to 7′ 8 or F E in elevation, Fig. 65. Then will 1″ 7″ 8″ 11″ 14″ be the half pattern which can be duplicated, as shown by similar figures to make the whole pattern. Allowance should be made for edges for seaming and riveting.

INTERSECTION OF AN IRREGULAR SCALENE CONE WITH A CYLINDER

The subjoined paragraphs tell how to obtain a pattern for a scalene cone mitering into a cylinder, the under side of the cone being horizontal. The intersection between the cone and outer line of cylinder is to be 22 inches and diameter of the cylinder, 20 inches, as shown in Fig. 70, in which A B C D E F G H is the side view of the article and O P R D^1 E^1 the plan. As C F in elevation is a given width, or 22 inches, and is wider then the diameter of the cylinder, which is 20 inches, the section at the base of the cone becomes an ellipse and therefore constitutes an irregular form and may be constructed as follows: Bisect the width of the cylinder A B or H G by the center line L M. Extend the sides of the cone D C and E F until they meet the center line L M at K and J respectively. Then will K J be the length of the base of the cone and the width of the cylinder that of the base. Parallel to A H draw the line T U, making it equal in length to K J as shown by the dotted lines. Bisect the line T U at the point T^1. Through T^1, and at right angles to T U, draw the line W V, making it equal to the diameter of the cylinder, as shown. Then through the points T, V, U, W draw any oblong figure as shown, which will represent the base of the cone. In the same manner, at right angles to D E, and from points D and E, draw lines, as shown, intersecting the line T U at X and U. Bisect X U at X^1. Then, with X^1 as center and X^1 X or X^1 U as radius, describe the circle X Y U Z which represents the section on line D E in side elevation.

The next step is to obtain the miter line or line of joint shown by C J^1 F in elevation, for which proceed as follows: Divide one half of the outer curve, shown from T to U, into any number of equal spaces as shown by the small figures 1 to

9. In the same manner divide one-half the inner circle into the same number of spaces, as shown from 9 to 17. Draw solid lines from 1 to 17, 2 to 16, 3 to 15, etc., until the last line 8 to 10 is obtained. At right angles to T U and from spaces 1 to 9, draw lines intersecting L M at points 1^1 to 9^1. In the same manner, at right angles to T U and from points 9 to 17, draw lines intersecting D E in elevation at points 9^1 to 17^1. Connect similar points with solid lines, as in section, thus: 1^1 to 17^1, 2^1 to 16^1, etc., until the last line 9^1 to 9^1 is obtained.

Now extend the line S P in plan as shown by S T^1. Upon this line place a duplicate of one-half of the sectional views with the solid lines connecting the same, as shown by T^1 V^1 U^1 Z^1 in plan. At right angles to O R and from the various spaces on the outer curve T^1 V^1 U^1, draw lines intersecting O R, or base of cone in plan, at points 1 to 9. In the same manner, at right angles to D^1 E^1, and from points in the half circle 9 to 17 draw lines intersecting D^1 E^1 at points 9 to 17. Connect similar points with solid lines, as in elevation thus: 1 to 17 and 9 to 9, 2 to 16 and 8 to 10, 3 to 15 and 7 to 11, 4 to 14 and 6 to 12, and 5 to 13, intersecting the circle P R S O at S, A^1, B^1, C^1 and R. Now at right angles to S P and from the various intersections on the quarter circle S R, draw lines upward, intersecting lines in elevation the numbers of which are similar to those in plan, as shown by the points C, F^1, G^1, H^1, J^1, K^1, L^1, M^1, F^1. Trace a line through these points, which will represent the miter line, or line of intersection between the irregular scalene cone and cylinder.

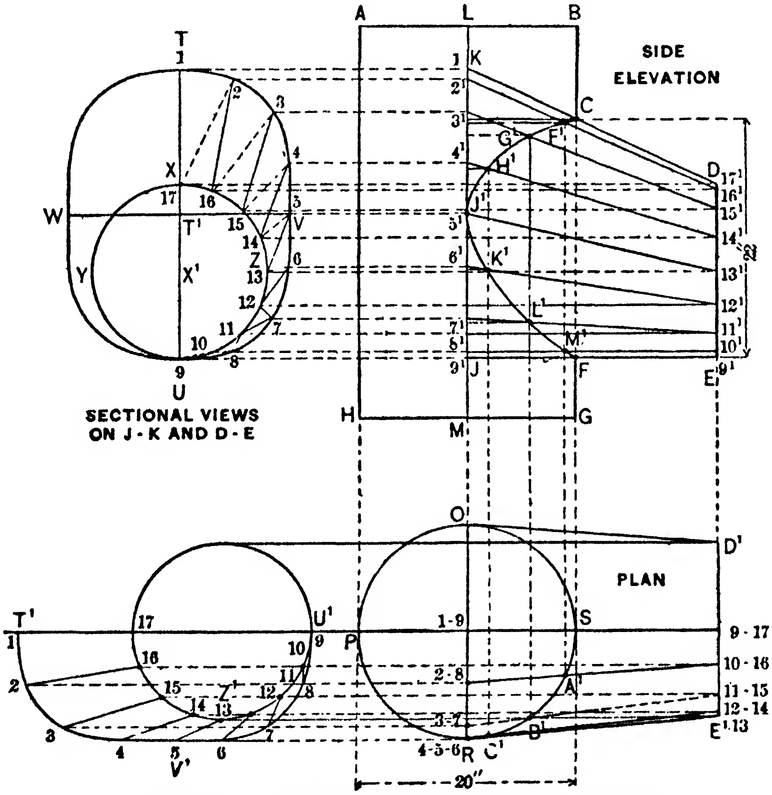


Fig. 70. Procedure for Obtaining Miter Lines

For the pattern of the opening to be cut in the developed cylinder proceed as follows: Duplicate A B C F G H of Fig. 70, as shown by A B C F G H in Fig. 71; also duplicate the plan O P R S with the various intersections, which have been numbered from 1 to 6 as shown. On the line G H extended, as O^1 R^1, place a stretchout of the half circle in plan, transferring each space separately, as shown by R^1 1 2 3 S^1 4 5 6 O^1. At right angles to R^1 O^1, and from the small figures, draw lines, which intersect with those of similar numbers drawn from the miter line C O^1 F at right angles to A H. Trace a line through the various inter-

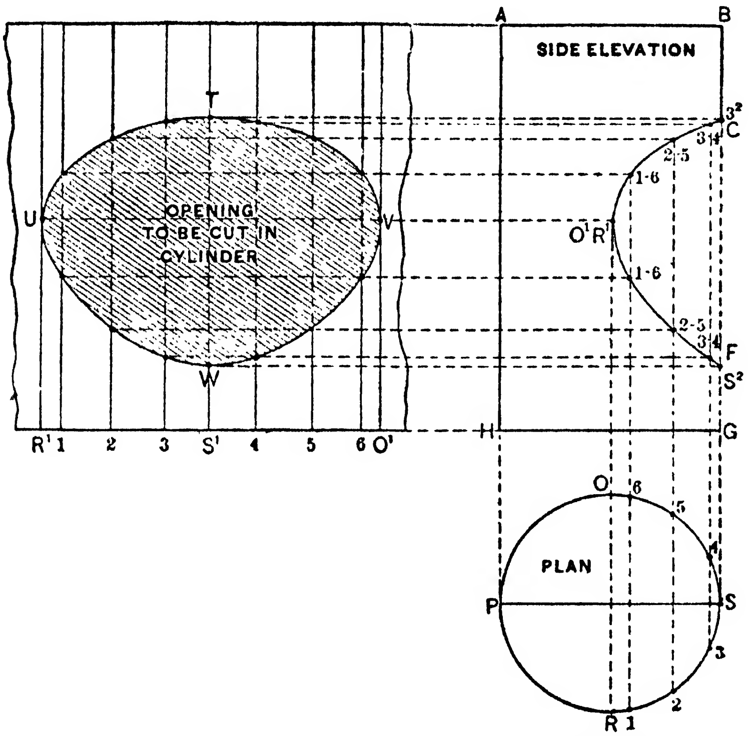


Fig. 71. Procedure for Obtaining Pattern of and Opening in the Cylinder

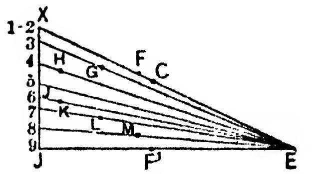


Fig. 72. Diagram of Triangles of Solid Lines

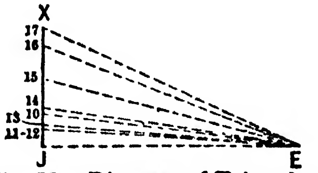


Fig. 73. Diagram of Triangles of Dotted Lines

sections. Then will T U V W be the shape of the opening to be cut into the surface of the developed cylinder.

For the pattern for the irregular scalene cone proceed as follows: From points in the base, Fig. 70, draw dotted lines to the top, as shown from 2 to 17, 3 to 16, 4 to 15, etc., until the last line 9 to 10 is obtained. Draw any horizontal line, as J E in Fig. 72, equal to J E in elevation, Fig. 70. At right angles to J E in Fig. 72 draw the vertical line J X, upon which place the various lengths of the solid lines shown in sectional views Fig. 70, as 17 1, 16 2, etc., measuring in every instance from the point J in Fig. 72, as shown by the small figures 1 to 9. From the small figures draw solid lines to the point E. Then will these solid lines

represent the hypotenuse of the triangles, the bases of which are shown in the sectional views, Fig. 70, by solid lines of similar numbers. In the same manner draw any horizontal line, as J E in Fig. 73, equal to J E in Fig. 70. At right angles to J E in Fig. 73 draw the vertical line J X, upon which place the various lengths of the dotted lines shown in sectional views in Fig. 70, as 17 2, 16 3, etc., measuring in every instance from the point J in Fig. 73 as shown by the small figures 10 to 17. From the small figures draw dotted lines to the point E. Then will these dotted lines represent the hypotenuses of the triangles the bases of which are shown in the sectional views in Fig. 70 by dotted lines of similar numbers. Draw any vertical lines 1 17, in Fig. 74 equal in length to 1^1 17^1 of Fig. 70 or 1 E of Fig. 72. Then with 1 2 of the sectional views, Fig. 70, as radius and 1 of Fig. 74 as center, describe the arc 2. Now with 17 E of Fig. 73 as radius and 17 of Fig. 74 as center, describe an arc intersecting the previous arc at 2. Then, with 17 16 of the sectional views of Fig. 70, as radius and 17 of Fig. 74 as center, describe the arc 16, which intersect by another arc struck from 2 as center and E 2 of Fig. 72 as radius. Proceed in this manner, using alternately, first, the spaces on the outer curve in the sectional views of Fig. 70, then the hypotenuses of the triangles of Fig. 73, the spaces on the inner curve in the sectional views of Fig. 70, then the hypotenuses of the triangles shown in Fig. 72, until the last line 9 9^1 of Fig. 74, has been obtained. Trace a line through points of intersections thus obtained. Then will 9 9^1 17 1 be the half pattern for the irregular scalene cone shown in the side elevation Fig. 70. by K D E J.

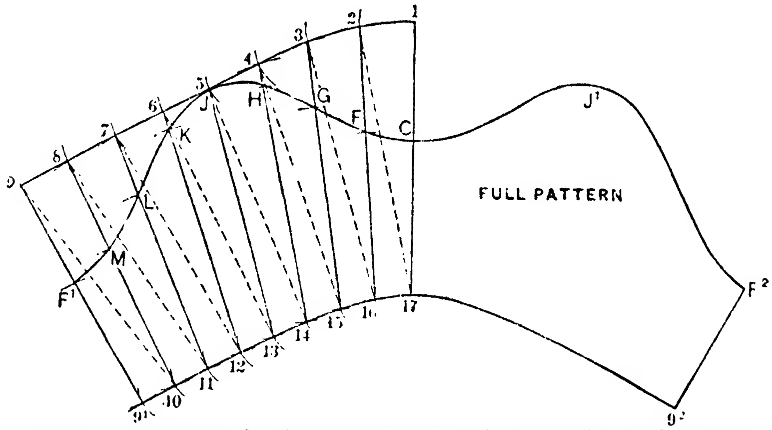


Fig. 74. Procedure for Obtaining Pattern for Irregular Scalene Cone

To obtain the cut or intersection with the cylinder proceed as follows: From the points of intersection C, F^1, G^1, H^1, J^1, K^1, L^1, M^1, F in side elevation Fig. 70, draw horizontal lines at right angles to L M, as shown. Take the distance of these horizontal lines, measuring in each and every instance from the line L M to the intersection on the solid lines, and transfer these lengths on to solid lines of similar numbers shown in Fig. 72, measuring in each and every instance from and at right angles to the line J X, obtaining the points C, F, G, H, J, K, L, M, F^1. On the

line 17 1 of Fig. 74, measuring from 17, set off the distance E C of Fig. 72, as shown at C, and from 16 on the line 16 2 set off the distance E F of Fig. 72, locating the point F. In the same manner set off E G of Fig. 72, on the line 15 3 and E H on the line 14 4, etc., proceeding in this manner until the point F^1 in the pattern has been obtained. Trace a line through points thus obtained, as shown. Then will F^1 J C 17 9^1 be the half pattern. Transfer a duplicate opposite the line C 17, as shown. Then will F^1 J C J^1 F^2 9^2 17 9^1 be the full pattern for the irregular scalene cone mitering against the cylinder.

PATTERN FOR AN IRREGULAR BOSS

To cut the pattern for an irregular boss, where the branch pipe is less in diameter than the main pipe, the following has been prepared. The branch, it should be stated, intersects the main at other than a right angle. Proceed as follows:

Let A B C D E F G H in Fig. 75, be the side elevation of the two pipes. At pleasure locate the points 1 and 7, giving the extreme length of the boss at the bottom, also locate the points 8 and 14, giving the horizontal line at the top. From the side elevation construct the end elevation, K representing the section of the main pipe, and 11 11° the top line of the boss. From 11 and 11° draw lines tangent to the circle K at 4 and 4°, respectively. The distance 4 4° and 11 11° represent, respectively, the widths at the bottom and top of the boss.

In line with the branch pipe in the side elevation draw the profile J, which divide into equal parts, as shown by the small figures 8 to 14. From these points parallel to B C draw lines intersecting the top line of the boss as shown by the figures 8 to 14. As any plane cut through a cylinder at other than a right angle produces an ellipse, then the elliptical section must be found through 8 14 in side elevation as follows: From the various intersections 8 to 14 on the top line of the boss draw vertical lines crossing the horizontal line S T in plan as shown. Now measuring from the line 8 14 in the profile J, take the various distances to points 9 to 13 and place them on each side of the line S T in plan on lines drawn from similar numbers measuring in each instance from the line S T. A line traced through points thus obtained will give the true section through the top of the boss, to fit around the cylinder B C D E at the angle shown.

From points 1 and 7 in side elevation project lines to the center line S T in plan, obtaining similar points 1 and 7. From the point 11 in the end elevation draw a vertical line intersecting the line 4 4° at *a*. Take this distance *a* 4 and place it in the plan of the side elevation from 11 to 4 on both sides. Through the

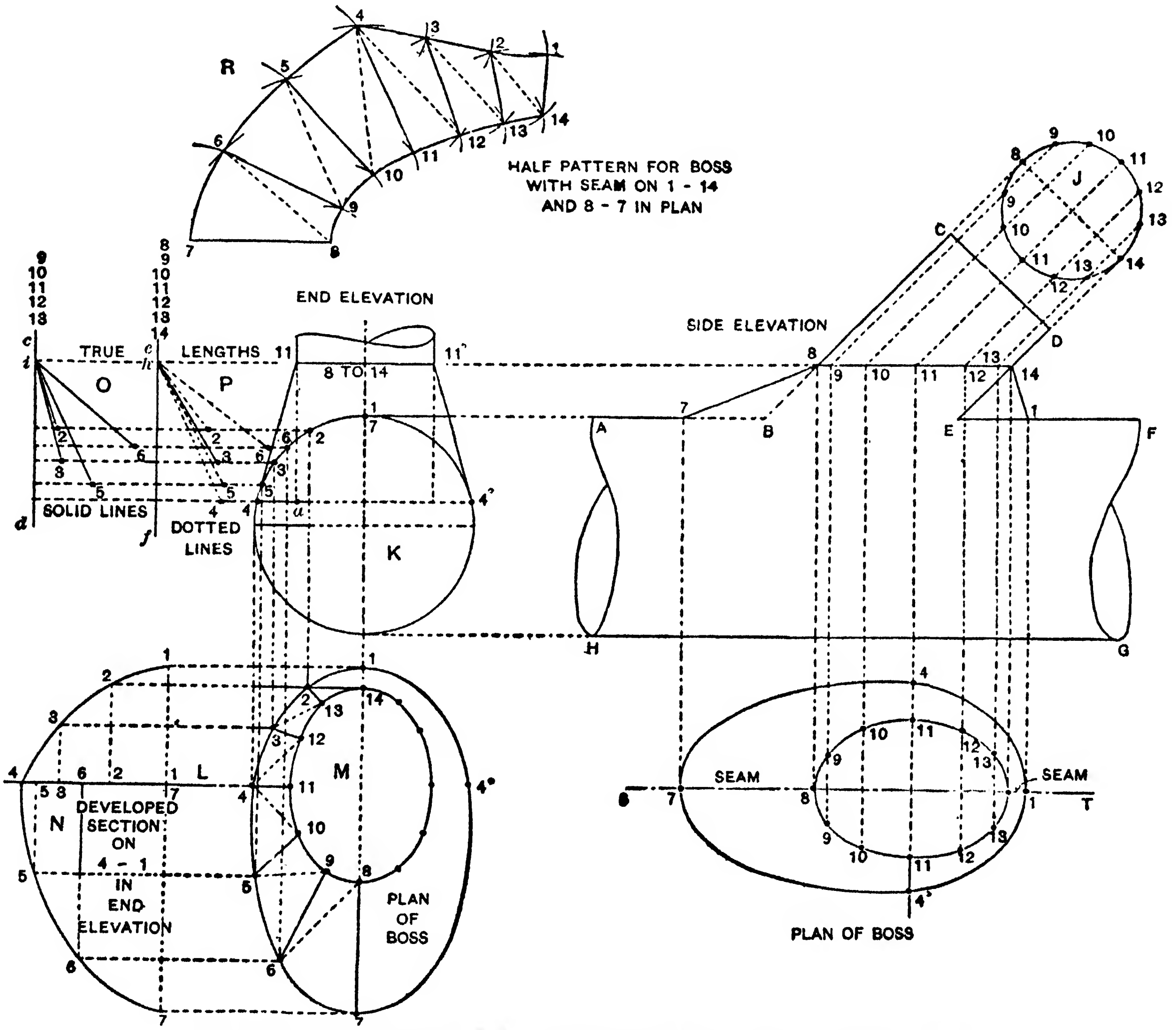


Fig. 75. Complete Process for Obtaining Pattern of the Irregular Boss

points 1 4 7 trace an elliptical figure at pleasure as shown, which will represent the miter line in plan between the boss and main pipe.

Take a tracing of this plan and place it below the end elevation as shown. As both halves opposite the line 1 7 are symmetrical, only one-half of the full pattern will be developed. As one-half of M contains six spaces, then divide one-half of 1 7 also into six spaces as shown from 1 to 7. Draw the solid and dotted lines

in the usual manner, and from points 1 to 7 in plan erect perpendiculars until they intersect part of the circle K as shown by points 1 to 7. As all the points from 8 to 14 in plan lie on a horizontal plane, shown by 11 11° in elevation, this line gives their proper hight and is so marked 8 to 14.

The obtaining of true lengths of the solid and dotted lines in plan can be accomplished rapidly by means of the diagrams O and P, the former being the true lengths on the solid lines and the latter the true lengths on the dotted lines. As 1 14 and 7 8 in side elevation and 4 11 in end elevation show the true lengths of these respective lines in plan, they need not be found in diagram O. From the various intersections 2 to 6 on the circle K project horizontal lines to be left as shown, and at pleasure erect two perpendiculars *c d* and *e f*. To obtain the true length of the line 6 9 in plan, take this distance and place it in O on the line drawn from 6 in the circle K, measuring from the line *c d*, and draw the diagonal line from 6 to *i*, *i* representing the upper line of the boss for all points from 8 to 14 in plan.

To obtain the dotted line from 3 to 13 in plan take this distance and set it off on the line drawn from 3 in the circle K measuring from the line *e f*, and draw a line from 3 to *h*; *h* in P representing the upper line of the boss for all points shown in plan from 8 to 14. In this manner obtain all of the solid and dotted lines.

Before the pattern can be developed a true section must be obtained on the curved line from 4 to 1 in K as follows: Take the various distances from 1 7, to 2, to 6, to 3, to 5, to 4 and place them on the horizontal line L 4 in plan, as shown by similar numbers, through which vertical lines are drawn and intersected by horizontal lines drawn from similar numbers 1 to 7 in plan. A line traced through points thus obtained as shown from 1 to 4 to 7 in N will be the developed section.

Assuming that the pattern is to be made in two halves with seam on 7 8 and 14 1 in plan below the side elevation, take the distance 7 8 in side elevation and place it as shown by 7 8 in R. With radius equal to 7 6 in the developed section N, and 7 in R as center, describe the arc 6, which intersect by an arc struck from 8 as center, with a radius equal to *h* 6 in P. With radius equal to 8 9 in plan M and 8 in R as center, describe the arc 9, which intersect by an arc struck from 6 as center and 6 *i* in O as radius. Proceed in this manner in developing the half pattern, noting the direction in which the solid and dotted lines run in plan M, obtaining the length of 4 11 and 1 14 in the pattern R, from 4 11 in end elevation and 1 14 in the side elevation, respectively. Trace a line through intersections thus obtained in R, which will then be the half pattern for the boss.

PATTERNS FOR AN IRREGULAR TEE JOINT

This exemplification treats on laying out an irregular tee joint. The main pipe being 20 in. in diameter, and the branch pipe oval in shape, 20 in. at the top and 40 in. at the intersection, as shown in Fig. 76.

The side and end elevations are given in Fig. 76, showing a 26 in. horizontal pipe being intersected by a branch pipe, the diameter of which at the top is also 20 in., but intersection with the horizontal pipe is 20 in. wide by 40 in. long. This gives an opening which freely allows an in or out flow of air to avoid friction. The principles explained herewith will be found applicable, no matter whether the pipes have similar diameters or not, or whether the branch pipe intersects the main in the center or to one side.

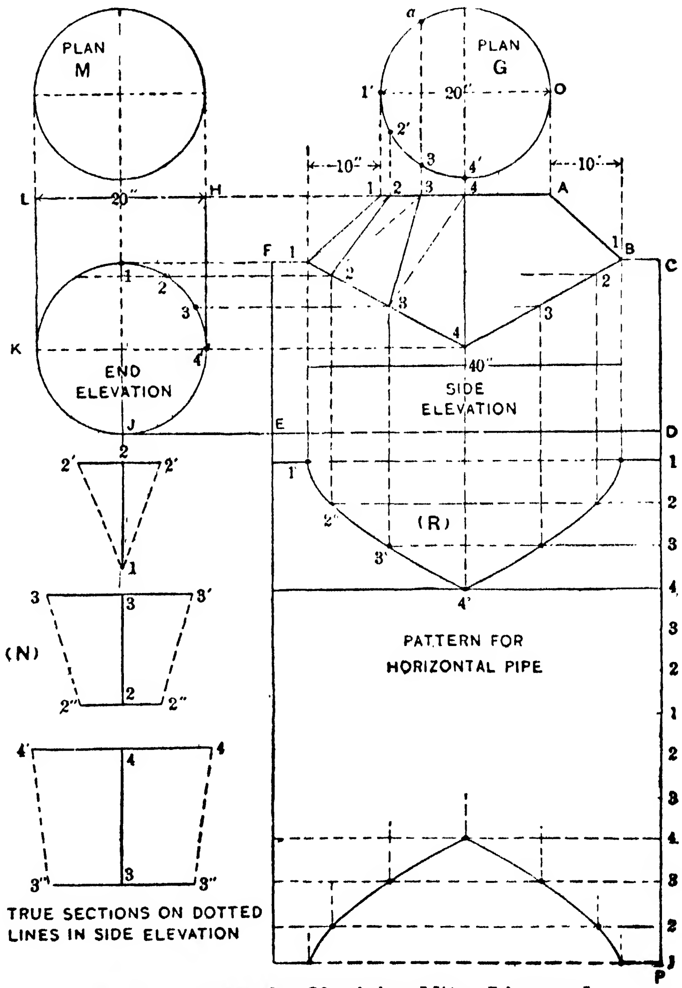


Fig. 76. Process for Obtaining Miter Lines and Pattern of Straight Pipe

Let A, B, C, D, E, F, 1, 1, A be the side elevation of the tee, F E being 20 in., A 1 20 in. and B 1 40 in. In its proper position draw the end elevation as shown by L, H, J. Then 1, 4, J, K represents the profile on F, E. In its proper position above A 1 in the side elevation draw the plan G; also the plan M above L H in end elevation. From the intersection 4 in end elevation project the horizontal line into the side, meeting a vertical line drawn from the center of the branch at 4, and draw the miter line 1, 4, 1 in side elevation, as shown. Then 1 A 1 4 1 shows the side elevation of a transition piece, which must be developed by triangulation, while the opening in the main pipe can be developed by parallel lines.

As the branch pipe intersects the main directly in the center it will only be necessary to develop the one-quarter pattern, the four quarters being alike. Therefore, divide one-quarter of the main pipe in end elevation into equal spaces, as shown, from 1 to 4, from which horizontal lines are drawn, intersecting the miter line in side elevation, as shown, from 1 to 4 to 1. In similar manner divide one-fourth of the plan G representing the top opening of the branch, also into similar spaces, as in end elevation, as shown from 1′ to 4′, from which perpendicular lines are drawn, cutting 1 A from 1 to 4.

Draw solid lines from 1 to 1, 2 to 2, 3 to 3 and 4 to 4, and dotted lines the shortest way from 1 to 2, 2 to 3 and 3 to 4. These lines then represent the bases of sections the altitudes of which are obtained from the end elevation and from plan G, as will be explained. As the diameter of the plan G and that of the end elevation J are equal, and as the number of spaces in both are alike, the solid lines shown in the transition piece in side elevation will show their true lengths, because the various distances, measured from the center line 1′ O in plan G to the various points 2′ to 4′, will be found similar to the various distances in the end elevation, measuring from the center line J 1 to points 2 to 4.

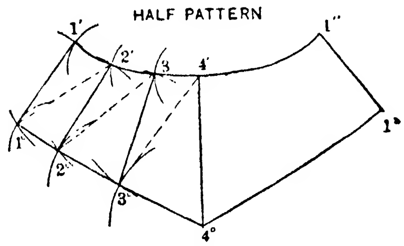


Fig. 77. Process for Obtaining Pattern of Irregular Tee

The true length on the dotted lines 1 2, 2 3 and 3 4 in side elevation are found by taking these distances and placing them on vertical lines in diagram (N), as shown by similar numbers. For example, to find the true length of the line 2 3 in side elevation, place this distance as shown by 2 3 in (N), through which points draw lines indefinitely. As the distance through 3 of the line 1 A in side elevation is equal to 3′ *a* in plan G, take one-half of this, as *a b* or *b* 3′, and place it in (N) on either side of the center line as indicated by 3 3′. In similar manner, as the distance through 2 on the miter line 1 4 in side elevation is equal to *d* 2 in end elevation, then take one-half of this, as *d* 1 of 1 2, and place it on either side of the center line in (N), as shown by 2 2″. Draw the lines 3′ 2″ and 2″ 3′, when 3′ 3′ 2″ 2″ represents the true section on the plane 3 2 in side elevation. In practice only one-half of these sections are required in (N).

The next step is to develop the opening in the main pipe, shown at (R), which will give the true lengths of the miter line and will be used in developing the branch pipe. On the line C D extended draw D P, upon which place the stretchout of the profile J in end elevation, as shown by similar numbers on D P. Through these figures draw the usual measuring lines at right angles to D P, which

intersect by lines drawn parallel to D P from similar numbered intersections on the miter line 1 4 1 in side elevation, and resulting in the intersection shown from 1° to 4° in (R). Trace a line through points thus obtained and this will give the pattern for the horizontal pipe, with a seam along C F in side elevation.

The pattern for the branch is now laid out by taking the distance of 4 4 in side elevation and placing it on the vertical line in Fig. 77 as shown by 4′ 4°. With radius equal to 4° 3° in the pattern (R) and 4° as center, describe the arc 3°, which intersect by an arc struck from 4′, in Fig. 77, as center, and 4′ 3″, in diagram (N) in Fig. 76, as radius. Now with 4′ 3′ in plan G as radius and 4′ in Fig. 77 as center, describe the arc 3′, which intersect by an arc struck from 3°, as center, and the solid line 3 3 in the side elevation in Fig. 76 as radius. Proceed in this manner, using alternately first the divisions in the miter cut (R), then the true lengths in (N), and the divisions in the plan G, and then the true lengths shown by the solid lines in side elevation. Through points thus obtained in Fig. 77 trace the line 4′ to 1′ to 1° to 4°, which represents the one-quarter pattern. If the pattern is desired in two part, trace this quarter opposite the line 4′ 4°, as shown by 1″ 1ˣ, which gives the half pattern with a seam on 1 1 and A 1 in side elevation in Fig. 76.

PROBLEM OF THE PATTERN FOR SPIRAL CONVEYOR

The question has several times been asked, how to cut a pattern for a spiral, such as is used as a conveyor or for the purpose of bolting in a flour mill, or as a conveyor for fertilizing compounds, flax and cotton seed and grains, white lead, concrete and many other materials, and also as a package chute. The question has always been answered by saying that a correct pattern cannot be cut, for the reason that the construction of such a spiral requires more or less stretching of the metal. From the purposes for which it is used it will be seen that when used as conveyors they must be more or less perfect in their curves and construction, according as the material to be conveyed offers more or less resistance.

The curved or twisted surface of such a conveyor is geometrically known as a helicoid, and may be described as a warped surface generated by a line (or some portion of a line) placed at right angles to an axial line, one end of which generating line is kept in contact with the axis, along which it passes at a uniform speed, while the other end of the generating line is revolved about the axis, also at a uniform rate of speed. The outline of the helicoid, or the path traversed by the extreme point of the generating line, is called a helix, and the ratio existing

between the two rates of speed for any given length of generating line constitutes what in mechanics is called its pitch. Thus the greater the speed of the generating line along the axis in proportion to the speed of its revolution the greater or higher will be the pitch and distance traveled by the outer end of the line at each revolution. The line at the top or bottom of a screw thread is a helix while the bearing surface (not the cylindrical surface) of a square thread is a helicoid.

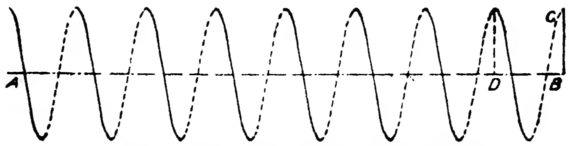


Fig. 78. Spiral or Helix of Low Pitch

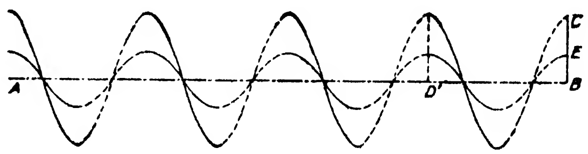


Fig. 79. Outer and Inner Edges of Helicoid of High Pitch

In Figs. 78 and 79 A B are the axes, B C the generating lines, and the spirals shown are the paths traversed by the points C as they revolve about the axes, while B C at the same time moves toward A. In Fig. 78 the line B C has during one revolution traveled the distance B D, while in Fig. 79 it is represented as having traveled twice as far (B D^1), thus producing a spiral or helix of much greater angle of inclination. As intimated above, the inclination of the spiral also depends upon the length of the generating line or distance of the point C from the axis. If another point be assumed upon the generating line nearer the axis than C, as E in Fig. 79, it will be seen that another spiral will be described, with an inclination greater than that described by the point C. The helicoid or surface existing between the two spirals in Fig. 79, or, in other words, the surface generated by the line C E, constitutes in the abstract that which, if executed in metal, would be required to form the essential feature of a spiral conveyor.

A helix may also be described as the line traced upon the surface of a cylinder by a point which is moved at a uniform rate of speed parallel to its axis while the cylinder is being rotated also at a uniform speed. The angle of inclination of a helix may be accurately obtained by constructing a right angle triangle the altitude of which is equal to the distance traversed by the point measured parallel to the axis of the cylinder at one revolution, as B D in Fig. 80 and the base of which is equal to the circumference of the cylinder, the hypotenuse of the triangles showing the required angle. In the triangle X Y Z, in Fig. 80, X Y is equal to the desired longitudinal distance traveled by a point at one revolution of the cylinder, while Y Z is equal to the circumference of the cylinder as taken from the plan above.

The hypotenuse X Z therefore gives the angle of inclination, and at the same time the exact distance measured around the cylinder and along the spiral line from B to D. If such a triangle, the base of which is equal to the circumference of a given cylinder and which altitude is any desired distance, be cut from paper and wrapped around the cylinder, having first placed its altitude parallel to the axis, or, in other words, so that its base shall lie in a perfect circle, the point Z meeting the point Y, as shown at D in Fig. 80, then a true helix may be traced along the hypotenuse upon the surface of the cylinder.

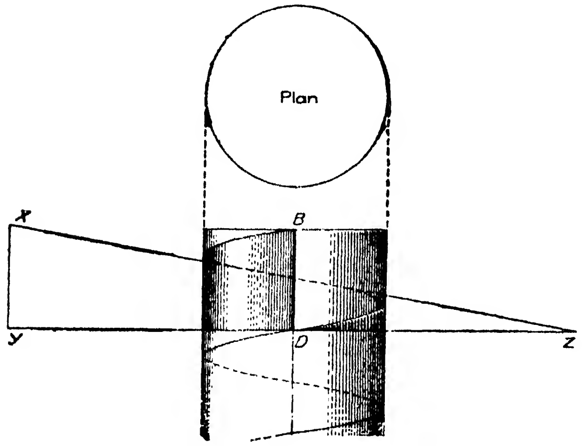


Fig. 80. Obtaining the Inclination and Length of a Helix

In Fig. 81 A B C D is the elevation of a portion of a cylinder or shaft around which it is required to construct a helicoid conveyor, E F being the required outside diameter of the flange, or flight, as that portion of the conveyor is some times termed. A half revolution of the flange is also shown in plan by H I J M L K, and in elevation by D B G E. The method of obtaining a correct elevation of the spiral line in elevation is shown in the left half of the drawing and may be described as follows: Divide one-fourth or one-half a revolution of the desired spiral line in plan into any number of equal spaces, as shown between K and L, also divide the same fraction of the hight of one revolution in the elevation into the same number of equal spaces, as shown by the points *a* to *e* upon the axis, and from these points draw horizontal lines above that portion of the plan similarly divided. From each of the points *b*, *c* and *d* of the plan erect a line cutting that of similar number of the elevation, as shown by the dotted lines. A line traced through the points of intersection, as shown from E to *a*, will give the required line in elevation. Lines drawn from *b*, *c* and *d* to the center P will give points upon other concentric lines of the plan from which to obtain their respective elevations by means of the horizontal lines previously drawn. Thus D *a* is obtained from the points on the arc H I, as shown.

As stated at the outset, the flange cannot be made without a certain amount of stretching of the metal to give it the required twist, which will be more or less according as the angle required is greater or less. If the angle required were lower

than that indicated in Fig. 78 it is possible that the metal might be cut in disks (one for each revolution) of the diameter shown in the plan, and forced apart sufficiently with little difficulty. But as the inclination increases the difficulty of construction increases also. In Fig. 81, therefore, an extremely sharp angle has been chosen in order to more clearly show the existing conditions and to make certain differences more apparent. Before these differences can be explained it will

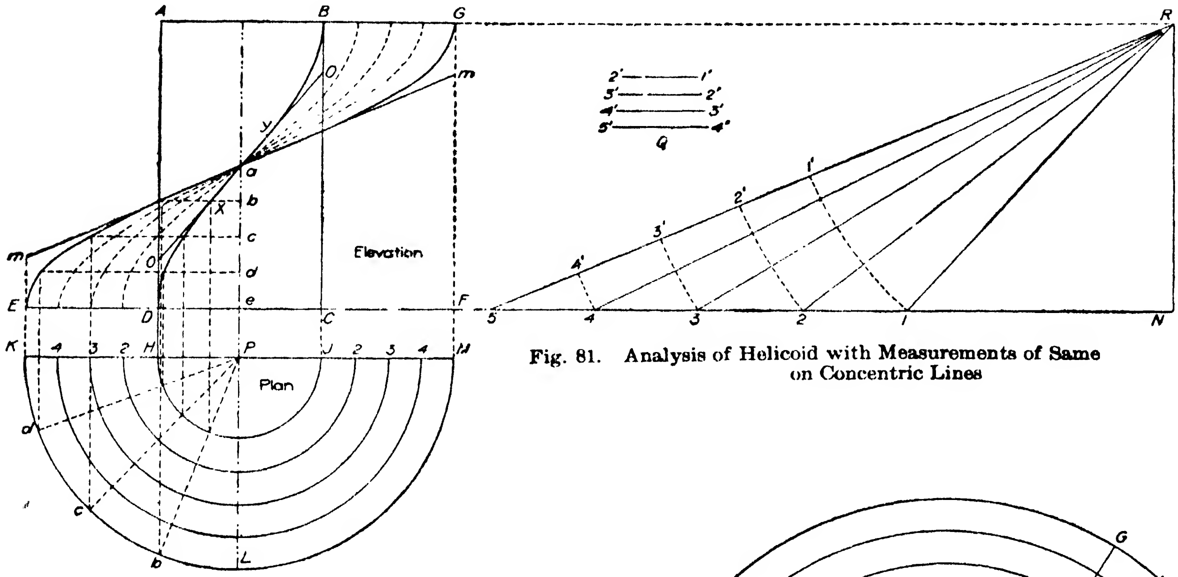


Fig. 81. Analysis of Helicoid with Measurements of Same on Concentric Lines

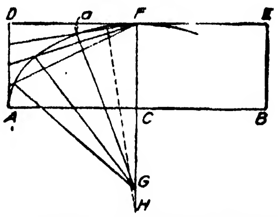


Fig. 82. Method of Obtaining Radius for Inner Side of Blank

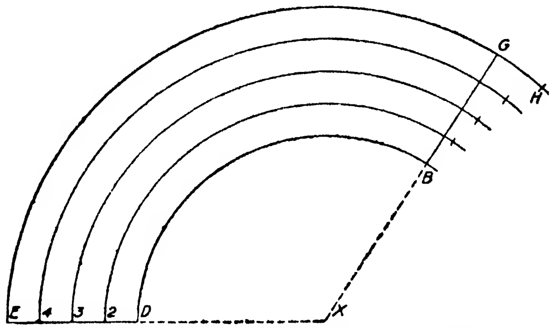


Fig. 83. Pattern for Blank Using Radius Obtained in Fig. 88

be necessary to first understand certain relations existing between circles and their diameters. The circumference of every circle, as is well known, is about three and one-seventh times its diameter. The relation of the diameter to the circumference of a circle cannot be given exactly in figures, but in all computations requiring ordinary accuracy 3.1416 is used as the multiplier of the diameter. The semicircumference H I J is therefore equal to one-half the product of the diameter H J multiplied by 3.1416. In like manner K L M is equal to one-half of 3.1416

times K M; and since the diameter K M is greater than H J by twice the distance J M, the semicircle K L M must be greater than the semicircle H I J by an amount equal to 3.1416 times J M (one-half the difference between the two diameters).

Following this, if K H or J M be divided into any number of equal spaces, and concentric semicircles be drawn, the differences between their circumferences will all be equal, because, as above stated, each difference is the product of 3.1416 by one of the spaces in J M, and the spaces being equal the product must be equal. The distance J M (or H K) having been divided into four equal spaces and the semicircles drawn, the circumference of each with those of H I J and K L M have been set off on the line E F extended, measuring each time from the point N. Thus N 1 is the circumference or stretchout of the line H I J, N 2 is that of the line 2 2, N 3 that of 3 3, etc., showing what has been proved by figures—viz., that the differences are all equal—that is, 1 2, 2 3, 3 4 and 4 5 are all equal. What is true of the set of equally spaced arcs of the plan is equally true of any other similar set of equally spaced arcs including a greater or less number of degrees than the semicircle, provided the arcs are terminated at either end by radii (lines drawn to the center from which they were struck)—that is, their differences would all be equal.

The several dimensions on the line N E having been obtained, the real stretchout on each of the parallel lines of the completed flight, represented in plan by the semicircles and in the elevation by the dotted spiral lines, may be easily obtained by completing the right angled triangle as described in connection with Fig. 80. Therefore erect the perpendicular N R equal in hight to A D and draw the hypotenuses R 1, R 2, etc.; then will R 1 be the correct length of the line D B of the elevation, or H I J of the plan, and R 5 the true length of B G of the elevation, or K L M of the plan. In the same manner R 2, R 3 and R 4 will be the correct stretchouts of the three intermediate parallel lines indicated by 2 2, 3 3 and 4 4 of the plan, and shown dotted in the elevation. A comparison of these distances, R 1, R 2, etc., will now show why a flat pattern for any portion of a flight cannot be cut. With R as a center describe arcs from each of the points 1, 2, etc., bringing all to the line R 5, from which it will be found by measurement that 1′ 2′ is less than 2′ 3′, 2′ 3′ less than 3′ 4′, and it less than 4′ 5′. A comparison of these differences is given at Q, where the short lines correspond in length with spaces of similar number on R 5. Any pattern, therefore, for a blank to form a portion of a flight, supposing it to be drawn to any determined or assumed radius and terminated at each end, as it must be by radial lines, would have to be

possessed of stretchouts taken upon equally spaced concentric lines, the differences of which were unequal, a condition which, as shown above, cannot exist in a flat pattern.

In determining the proper radius by which to lay out a blank to be raised or stretched into the required helicoid two methods are open to the mechanic: One is to obtain as nearly correct a curve as possible of the right length or stretchout for the inner side of the pattern, then draw the outside of the blank parallel to it, in width equal to B G or J M, and finish by stretching the outside and intermediate portions with the hammer until they reach the required position, as shown by E G and the parallel dotted lines of Fig. 81. The other method is to reverse the operation, obtaining first the outer curve and work to the inside. An inspection of the elevation will show that both of the spiral curves near where they cross present the appearance of nearly straight lines for a considerable distance. The central or nearly straight portion of the inner spiral D B, for instance, would, if prolonged in either direction, cut the outlines of the cylinder around which it is drawn at the points *o* and *o*; and as any section of a cylinder taken on an oblique plane is an ellipse, it will be seen that that portion of an elliptical section of the shaft taken on the line *o o* and lying between the points *y* and *z* must very nearly approximate the inner curve of the spiral. But as the curve of the spiral is unlike the ellipse, the same at every part, the required portion of the ellipse having been drawn, the approximate radius of that portion can be used in describing the pattern for the required blank.

This radius can be quite easily obtained in the following manner:

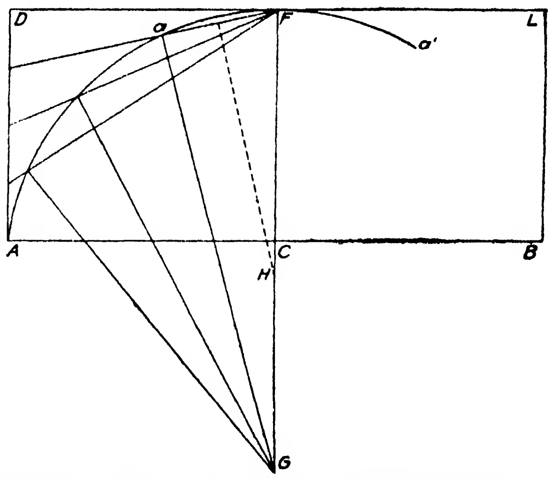


Fig. 84. Method of Obtaining Radius for Outer Side of Blank

Draw any line, as A B of Fig. 82, equal in length to *o o* of Fig 81, which bisect at C. At A, B and C erect three perpendiculars, which make equal in hight to I P of Fig. 81, the semi-diameter of the shaft, and draw D F E. Prolong F C, making C G equal to C F. Divide A C into as many equal spaces as sets of centers are desired for drawing the ellipse, in this case four, and divide A D into same number of equal spaces. From points in A D draw lines to point F, and from G draw lines through the points in A C and continue them till they

intersect the first set of lines, as shown. Bisect the distance from the first intersection, a, to F and from the middle point draw a line at right angles to a F and prolong it till it intersects F G (extended if necessary) in H. This will give the radius for that portion of the ellipse from a to a^1. It will not be necessary to complete the problem, as the other portions of the ellipse will not be required.

To describe a pattern for a blank, first, with a radius equal to F H of Fig. 82, draw any arc, as D B of Fig. 83, which make equal in length to R 1 of Fig. 81. From the center X draw the radii X D and X B, extending them indefinitely beyond D and B. Upon X D set off the width of the flange, as shown by D E, and draw the arc E G. Then D E G B will be the required pattern for the blank for one-half a revolution of the flight, as shown by the plan in Fig. 81.

The necessary amount of stretching which the blank will require can be found in the following manner: First, divide E D into four equal spaces by the points

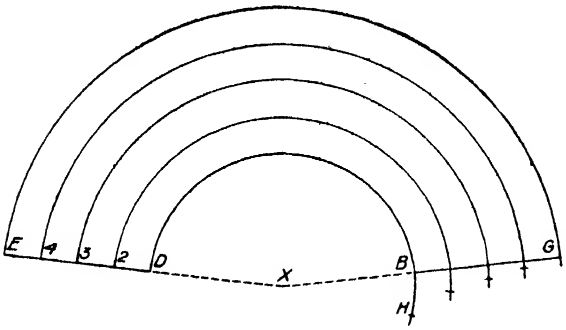


Fig. 85. Pattern for Blank Using Radius Obtained in Fig. 85

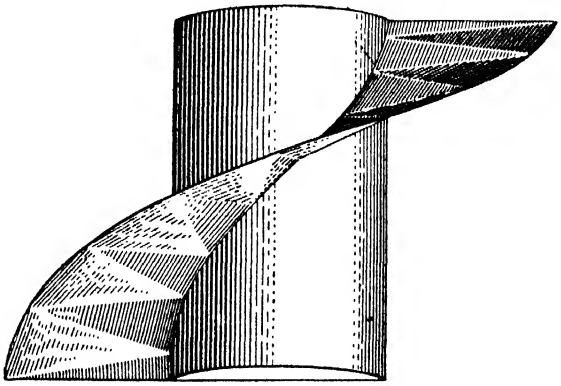


Fig. 86. Portion of Helicoid Obtained by Triangulation

2, 3 and 4, corresponding to those of the plan in Fig. 81, and draw the concentric arcs shown, extending them with the outer arc beyond the line B G. Upon each of these arcs, measuring from E D, set off their required stretchouts as obtained from corresponding hypotenuses in the diagram of Fig. 81. Thus make arc 2 equal in length to R 2 of Fig. 81, arc 3 equal to R 3, arc 4 equal to R 4, and the outer arc equal to R 5. From this it will be seen that the outer arc E G of the blank must when the flange is finished be equal in length to E H; and that in like manner the flange must measure upon each of the intermediate arcs distances greater than those included between the two radii X E and X G by amounts equal to the distances of the several points on them beyond the line B G. The pattern cannot be cut to the points between B and H, but must be cut off on

the line B G and stretched as described. If it be required to place a line of any given length so as to be entirely over a shorter line it can only be accomplished by elevating one end more than the other. Thus the stretching of the metal upon any one line or arc gives it the required elevation or inclination as compared with the adjacent arc, which is stretched less or not at all, thus producing the twist.

If it be desirable to adopt the second method referred to above—viz., that of obtaining the outside line of the pattern first—the operation can be performed in exactly the same manner as above described, using the outer spiral of the elevation in Fig. 81 instead of the inner one. Continue its central or nearly straight portion to the outlines of the cylinder in the surface of which it lies, as shown at *m* and *m*, and use the line *m m* as the major axis of a semi-ellipse and proceed as described in the case of line *o o*. This operation is shown in Fig. 84, in which A B is made equal to *m m* and A D equal to L P of Fig. 81. Following this the operation is identical with that described in connection with Fig. 82, and the same reference letters have been used, so that the description may be followed if desired. In obtaining the final result in the latter case, however, the point H is found to fall between C and G, and H F, the radius obtained, is used to describe the outside line E G of the blank shown in Fig. 85. The arc E G of Fig. 85 having been drawn and made equal in length to R 5 of Fig. 81, and the radii E X and G X also drawn, E D is made equal to E D of Fig. 81, and the pattern for the blank completed by drawing the arc D B. The amount of stretching necessary to bring this blank to its required shape may be ascertained by drawing the concentric arcs as in Fig. 83, and extending them with the arc D B beyond the line B G, where the several stretchouts, taken from the diagram in Fig. 81, are indicated by points as before.

In the case of the blank shown in Fig. 83, which is drawn with the longer radius, the stretching of the metal upon the outer edge shortens or increases its curve until the line B G is elevated and brought into the same vertical plane as the line E D, while in the case of the one shown in Fig. 85, which is drawn with the shorter radius, the stretching of the metal upon the inner edge straightens its curve until the same result is accomplished.

In deciding which of the above methods is to be preferred, the mechanic should be the judge. It is usually considered easier to stretch the metal upon the inner side of a curved strip than upon its outer side, but it is possible and even probable that a middle course would be better than either of those above mentioned. For instance, the line 3 3 or 4 4 of the plan in Fig. 81, or any assumed line, might be made the base of the pattern, in which case the length of the major

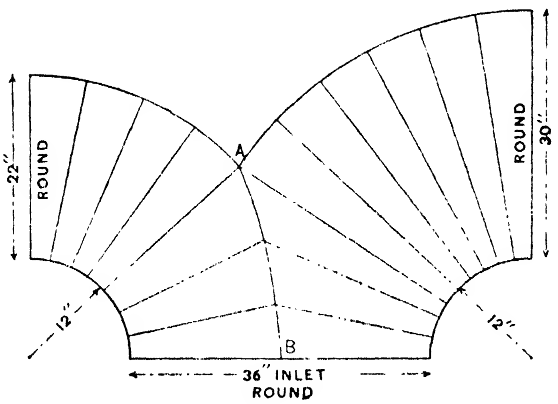
axis of an ellipse from which to derive its radius could be obtained by using a corresponding spiral line of the elevation the same as D B or E G were used to obtain the line *o o* or *m m*. Such radius having been obtained and the arc drawn, its length would be equal to a corresponding line of the diagram of Fig. 81 measuring from R. The required portions of the width, K H, could be set off on either side of the arc drawn, and the pattern completed by drawing the outer and inner arcs and the radial lines at the ends. Such a blank would then require stretching some on both edges to bring it to the required shape, the amount of which could be obtained as described in connection with Figs. 83 and 85.

Any pattern cutter familiar with the possibilities of triangulation in the treatment of irregular surfaces might reasonably ask if the pattern for a helicoid could not be cut by that method. It is true that a pattern for such a shape could be cut so as to be correct at its inner and at its outer lines; (see page 278 and279 of this volume) but, unlike the pattern for an ordinary transition piece, the bends at the several lines crossing the pattern (that is, the sides of the triangles used in obtaining the pattern) would not merge into one general curve, but the pattern would have to be really bent on each line to the exact angle existing between the inclinations of the two spirals between which it is contained. A flight completed by such a method would result in a sort of winding stair, in which the risers assume the angle of the inner spiral B D while the treads lie at the angle of the outer spiral E G of Fig. 81. In Fig. 86 is shown a pictorial sketch of a portion of a triangulated helicoid, from which it will be seen that if so made it would be useless for the purpose for which conveyors are intended; and that if a blank were so cut the metal (of which there is too much through the center) could not be contracted, while a pattern which has the right amount of metal in the center, but too little at the edges, could be stretched to meet the requirements.

IMPORTANCE OF GEOMETRICAL DRAWING TO PATTERN CUTTERS.

In replying to many of the correspondents who have requested solutions to pattern problems, *Metal Worker*has had frequent occasion to refer to the necessity of a more thorough knowledge on the part of the pattern cutter of the principles of geometrical or linear drawing. An inquiry of this class once came to hand in which the correspondent desired to know how to develop the complete patterns of two double pieced elbows as sketched in Figs. 87 and 88, which show what are

really two cases of the same problem. In Fig. 87 the two smaller pipes are placed in the same horizontal line at the throat, while in Fig. 88 they are in line on the back. In either case the problem with which the correspondent has to wrestle is one of draftsmanship rather than of pattern cutting. With two carefully completed



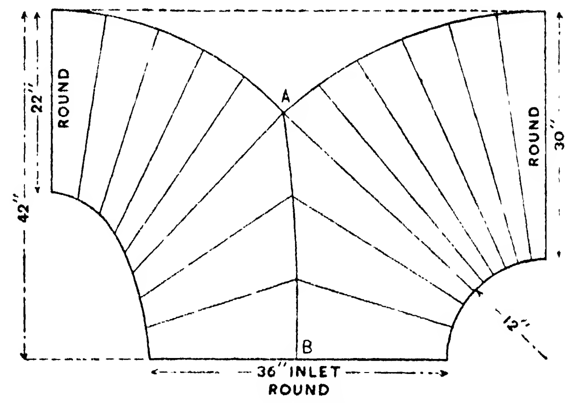


Fig. 87. Reproductions of Original Sketches Accompanying Inquiry Fig. 88.

elevations and a plan of the desired elbows, as specified in either of the above sketches, at hand, no doubt any fairly intelligent pattern cutter would have little difficulty in working out the patterns.

Pattern cutting is simply an adaptation of the principles of linear drawing to the development of sheet metal forms. That particular branch of linear drawing with which the pattern cutter has to deal is properly termed orthographic or right line projection. In accordance with its principles all the points of any one view or elevation are determined with accuracy by means of parallel lines projected from one or more other views (elevations or plans).

Thus the draftsman begins the construction of his principal view from given specifications and proceeds to project therefrom as many other views as possible, or as he finds necessary to arrive at the results desired. In the evolution of such a set of elevations and plans new facts are often brought to light as the work progresses which were unknown at the outset, and which as soon as obtained render their share of assistance in obtaining the final results. Such a course, supplemented by the fund of knowledge which comes with experience on the part of the draftsman, will often accomplish wonders.

This problem furnishes such an excellent opportunity of illustrating the application of the foregoing suggestions that the complete operation of constructing the necessary plans and elevations and of laying out the patterns for the above, as far

as necessary, beginning with the conditions as given in Fig. 87 is here consistently undertaken.

The principal view taken from first drawing any horizonal line indefinitely, as C D of Fig. 89, upon which set off at convenience the distance E F equal to 36 inches, the desired diameter of the inlet. From the points E and F set off 12 inches in either direction upon the same line, thus locating the centers G and D, from which the throat curves are to be struck. Erect perpendicular lines from the points G and D indefinitely. From G and D as centers, with a radius of 12 inches, describe arcs from E and F cutting the perpendiculars just drawn in the points M and K. From M and K set off respectively 22 inches and 30 inches upon the vertical lines, obtaining the points N and L. From D as center, with the radius D L, describe an arc, L A, indefinitely; and from G as center with G N as radius, describe another arc, cutting the first one in the point A. This completes the general outline of the side elevation.

Since three pipes of different diameters are to be joined, it is evident that there must be some gradations in the width of this elbow at the various points of its course. It will therefore be necessary to construct a plan or an end view, or perhaps both, upon which to establish such gradations and to measure width when necessary. The plan may be begun at once, and all of the views which is deemed necessary to construct should so far as possible be carried along together, all points in any one view being projected into the other views as soon as obtained. Since both halves of the elbow, when divided by a vertical longitudinal plane, are supposed to be alike, half of the plan or end view will be sufficient for all purposes. Therefore draw C^1 D^1 parallel to C D and at any convenient distance away, as the center line of a plan. From each of the points G, E, F and D drop lines vertically, cutting C^1 D^1 at G^1, E^1, F^1 and D^1, and continue them indefinitely below. Bisect E^1 F^1, obtaining the point B^1, which will become the center from which to describe the semicircle E^1 H F^1, representing the half plan of the inlet or largest pipe.

In drawing the miter line or line representing the junction of the two arms of the elbow, as seen in the side view, and in determining the shape of the opening which it represents as it would appear if seen from either end, the reader will have to be guided by his general knowledge of intersections and the shapes derived therefrom. Were the two pipes of the same diameter throughout their course, and brought or mitered together in the general manner indicated in the drawing, the position of the miter line would result from the simple operation of bringing together two sets of lines emanating from corresponding points in their respective profiles.

If, again, one pipe being larger than the other, both be continued without change of diameter as before through the several pieces composing the elbow, the position of the miter line upon which the two would intersect would be the result of a similar operation. But since the two branches or elbows are required to unite so as to

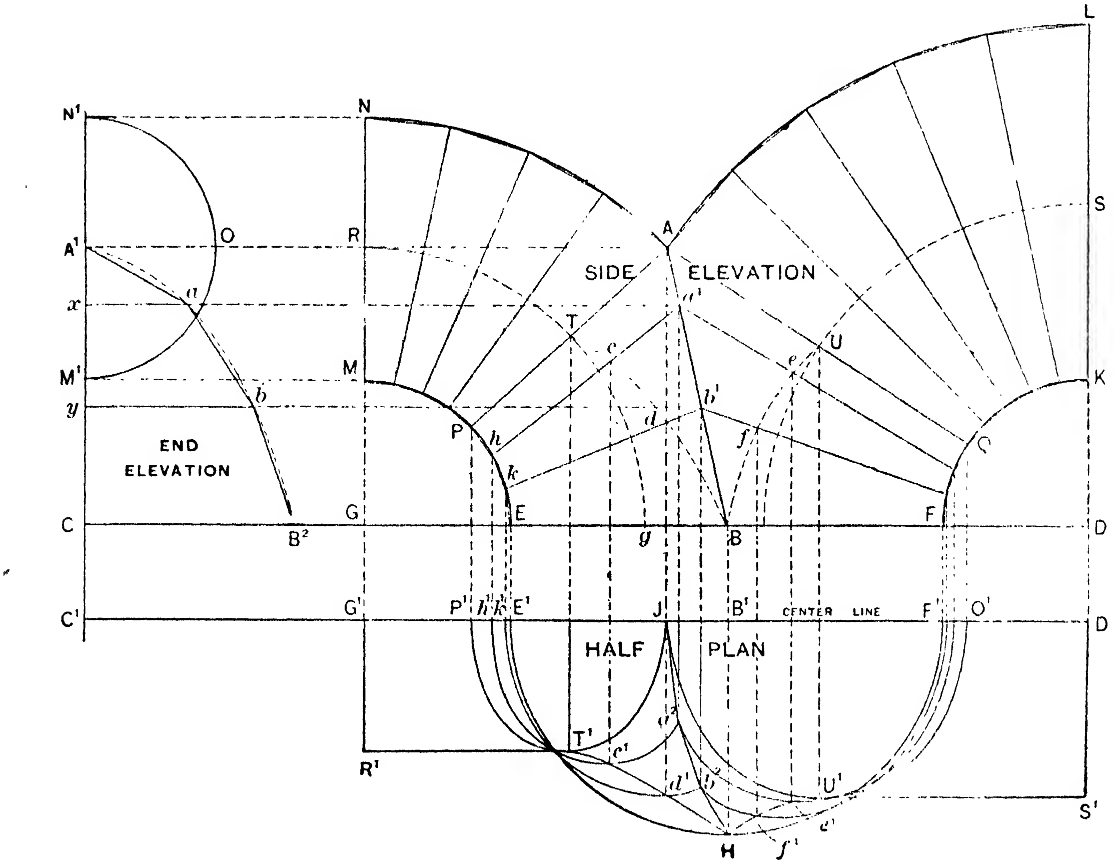


Fig. 89. Complete Drawings of Double Elbow shown in Fig. 87.—One eighth Full Size

form a third pipe of a specified larger diameter than either, the problem consists in the devising or designing of a transition composed of several pieces which shall begin at A with a junction of the two smaller pipes and finish at E F with a perfect circle representing the larger pipe.

In this part of the work the reader will have an opportunity to exercise the power of his imagination in forming a mental idea of the approximate shapes of the several intermediate pieces necessary to accomplish the transition, working upon the supposition that if he can form an idea of the general shape and dimensions of the several parts he will have little difficulty in placing the different views of them upon paper.

In the failure of his power of mental conception he could be materially aided in his work, should he care to take the trouble, by the construction of a model. An inspection of the drawing, as thus far constructed, will show at once that those portions of the branches from A to N and A to L will be the same as ordinary pieced elbows. Suppose now that these parts have been made in the usual way, and have been placed relatively in the positions which they are to occupy in the finished work. Let the reader now cut out a disk of any material and place the same in the position shown by E F of Fig. 89, then, taking moist clay or molders' sand, proceed to fill in the space E P A Q F between the approaching ends of the elbows and the disk at the base, shaping it so as to meet the curves of the throats at either end and gradually reducing its width or thickness as it rises till it meets the circles at A P and A Q. A model so constructed will give the general shape of the transition, upon which the several pieces of which it is to be constructed must be so outlined that they may be made by simply cutting and bending the metal.

Sooner or later in the solution of every problem in sheet metal work the question of the method of developing the patterns arises. Is it a miter or miters between continuous or parallel forms? Are the pieces portions of regular tapering cones, or are they irregular tapering forms, in which case triangulation must be resorted to? An inspection of the drawing as thus far developed, or of the model if it has been constructed, will show that those parts constituting the transition must be developed by the methods of triangulation, and that therefore their outlines may be drawn arbitrarily in accordance with the judgment of the reader, provided that they are not so drawn as to involve hammering or stretching of the metal.

To proceed then with the drawing in the light of the above conclusions, the miter line A B may be drawn straight from A, the point of least or no width, to B, the point of greatest lateral diameter or width of the united elbows. To be sure, it might be drawn from A to a point to the right or to the left of B if there were any reason for so doing, or it might be drawn with a general curve composed of as many straight lines as there are intersecting pieces on either side, but such a course would only complicate matters to no purpose. The line A B, representing as it does the junction of two pipes while appearing straight in this view must necessarily have a profile when viewed from the end. An idea of the shape which it represents could be obtained by cutting away one portion of the model described above by means of a thin bladed knife or a wire held taut and passed from the point A down through to B, the middle of the disk at the base. To obtain this

line without the aid of the model it will become necessary to construct an end view of the junction, as shown at the left in Fig. 89.

The end view is obtained by drawing any vertical line, as C N[1], representing the center line of the proposed view. Project the point A upon this line by means of the dotted horizontal line, as shown at A[1], and from C set off on the

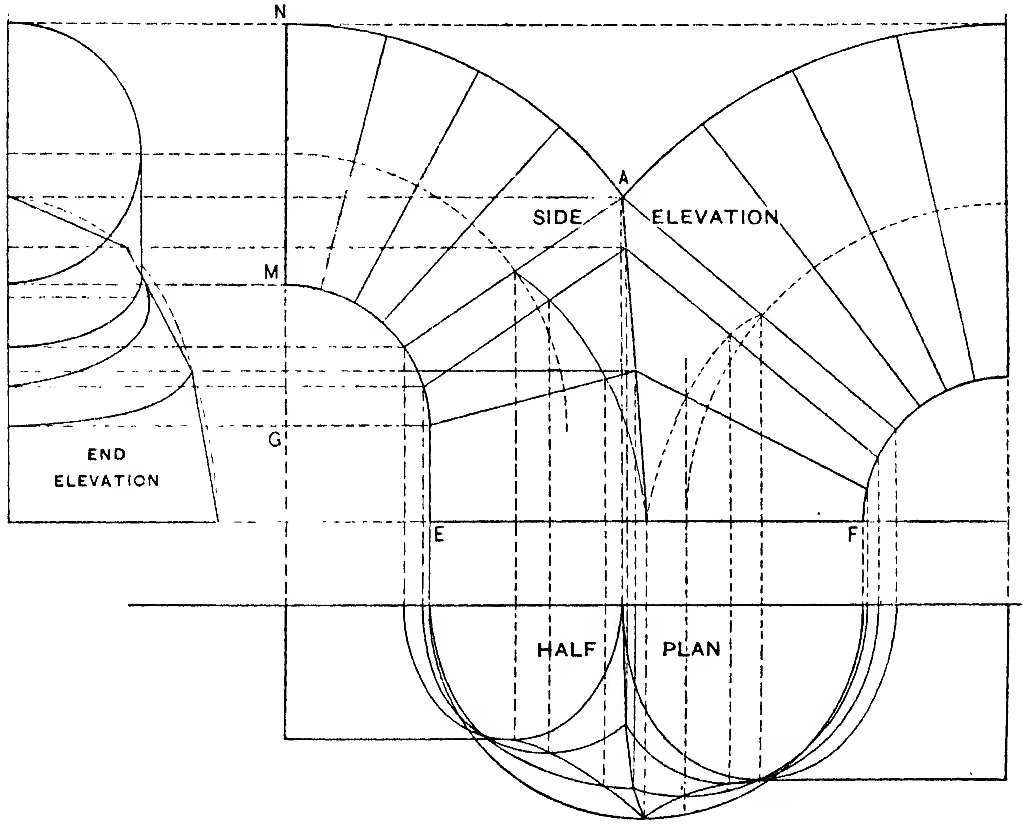


Fig. 90. Completed Drawings of Double Elbow Shown in Fig. 88.—One-eighth Full Size

horizontal base line one-half the width of the largest pipe—that is, make C B[2] equal to 18 inches. A line drawn from A[1] to B[2] will then represent one-half the opening between the two branches of the elbow. This line, so far as the requirements of triangulation are concerned, might be drawn perfectly straight between the two points. But here the knowledge or experience of the reader must be called into play. Any one who has seen two straight pipes mitered together so as to form a Y, or has cut any oblique miter upon a cylinder, knows that the shape of opening so produced is elliptical. It is therefore advisable that the line A[1] B[2] should approximate a quarter ellipse in shape, as shown by the dotted line in the end view.

This end view may be completed as far as desired, making it an elevation of the end nearest which it is drawn. Therefore project the points N and M horizontally from the side elevation to the center line of the end elevation, as shown at N^1 and M^1. Bisect the distance N^1 M^1, locating the point A^1, which by mere accident or coincidence falls at the point representing A of the side elevation. From A^1 as a center describe the semicircle N^1 O M^1, representing one-half the opening at N M to receive the 22-inch pipe. Lines from O toward B^2 may afterwards be drawn to complete this view if found necessary.

The next matter to be determined will be the number of pieces of which the elbows shall be made, and the drawing of the divisions upon the elevations in accordance with the same. The number of pieces will, of course, be determined in accordance with physical requirements; material to be conveyed, friction, etc. Having determined this, first draw lines from A toward G and D, as shown by A P and A Q. The portions A N M P and A L K Q thus become the equivalents of ordinary pieced elbows, and the arcs A N and A L being unequal may each be so divided into equal spaces that the spaces in both shall be approximately alike. Thus it will be seen that if N A be divided into four equal spaces and A L into five, they will be nearly alike in both. From the points of division assumed in N A and A L lines may now be drawn toward G and D to the throat lines, as shown. Connect adjacent points upon the arcs, both of the throats and the backs, by straight lines, thus completing these parts of the side elevation.

In continuing the division to the part forming the junction, the points of division corresponding to those already assumed on the backs of the pieces will have to be established upon the line A B; but as A B represents a curved line it will be better to fix the points of division upon its representative A^1 B^2 of the end elevation. Two points upon A B, dividing it into three spaces, will be found sufficient, since three equal spaces upon each of the remaining portions of the throat lines P E and Q F will result in an approximate equality of spaces in M E and K F respectively. Therefore the points a and b may be so taken upon the curved line A^1 B^2 that the space A^1 a will be the shortest and b B^2 the longest of the three. Connect the adjacent points by straight lines, as shown. By making the spaces shortest where the curve of A^1 B^2 is quickest, or of shortest apparent radius, the resulting broken line will more nearly approach the curved line which it takes the place of than if the spaces had been made equal. The points a and b may now be projected upon the miter line A B of the side elevation, as shown at a^1 and b^1, and straight lines drawn from each to the corresponding points of division upon the arcs P E and Q F.

In the thus completed side elevation the two upper sections of the transition piece lying adjacent to the lines A P and A Q have the appearance of being no wider at their backs than at their throats, but a moment's reflection or a glance at the end elevation will show that the distance of the point a^1 from A is equal to a A^1 of the end view, and that it is therefore greater than the back width of any of the other pieces except those between it and the line E F. One might easily have made the mistake of dividing the line A B of the side elevation into three equal spaces had the end elevation, showing the shape of the section on A B, not been drawn. This liability to error is, in fact, shown in the crude outlines of the original sketches given in Figs. 87 and 88.

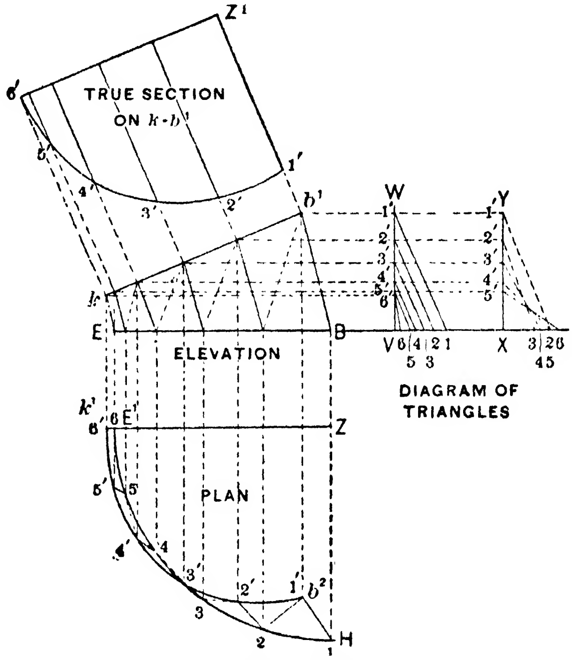


Fig. 91. Elevation, Plan and Section of First Piece, E k b^1 B, in Left Side, Duplicated from Fig. 89, Showing Method of Triangulation.

Attention is now directed to the completion of the plan, upon which must be obtained a view of each of the several miter or joint lines between P A Q and E F, including the line A B. The positions of the points in A B upon the plan are obtained simply by projection and measurement. The point A being upon the longitudinal center may be dropped at once to the center line of the plan, as shown at J. From each of the points a^1 and b^1 also drop lines to the center line, carrying them indefinitely beyond or below. Upon each of these lines respectively set off from the center line the distances a x and b y of the end elevation, as shown by a^2 and b^2. The point B being upon the circumference of the largest pipe may be dropped upon the semicircle representing the same in the plan, as shown at H. Connect the adjacent points obtained in this operation by straight lines; then the broken line J a^2 b^2 H will be the plan of the line A B of the elevation.

No further drawings will, of course, be necessary in obtaining the patterns of those portions between P A Q and the outlets. It will be advisable, however, to represent them in the plan on account of their relationship to the middle and more intricate portion. Therefore drop vertical lines from M and K through the

center line of the plan, and make G^1 R^1 and D^1 S^1 respectively equal to the semi-diameters of the outlets M N and K L. From R^1 and S^1 draw lines parallel to G^1 D^1 indefinitely toward the center of the plan.

The next operation will be to obtain upon the plan a projection of the circles P A and A Q. First bisect the lines representing those circles, as shown at T and U. Since T and U represent points of extreme projection or points of greatest transverse diameter, vertical lines may be dropped from them, cutting the lines drawn from R^1 and S^1, as shown at T^1 and U^1; also drop lines from P and Q cutting the center line of the plan at P^1 and Q^1. Then P^1, T^1 and J become three points of a semi-ellipse of which P^1 J is the minor axis; and likewise J, U^1 and Q^1 are three points of a semi-ellipse of which J Q^1 is the minor axis. These semi-ellipses may be drawn upon the plan by raking, by trammel or by any method most convenient which will result in true elliptical curves.

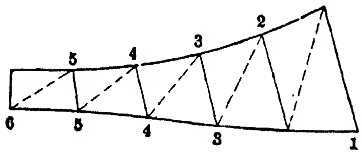


Fig. 92. Half Pattern of Piece Shown in Fig. 91

Having now drawn the plans of the circles constituting the upper and lower sections of the transition portion of the elbow, it remains to fix upon the plan the sections upon the two intermediate joint lines in each side or branch. Inasmuch as the method of triangulation admits of working to assumed outlines, the draftsman is here thrown upon his judgment as to the shape of and the best method of obtaining these sections. This can be accomplished by first establishing the principal points of the curves and then drawing them by eye so as to form in each branch a gradual transition from the circular profile of the small pipe to one-half the circle of the large pipe or inlet. The first points to be determined are those of greatest thickness or transverse diameter in each. The point of greatest transverse diameter in each of the joint lines in the smaller branch pipe is, of course, at the intersection of each with an arc drawn from G as center and with G R as radius, that of P A being at T. This arc continued intersects the line E F at *g*. But as the greatest transverse diameter of E F is at B the points *c* and *d* must be assumed so as to deflect this line at T toward B. Having determined the points of greatest thickness upon these lines the question next arising is: "What shall be the distance across the sections at these points?" This must, of course be determined upon the plan, where T^1 represents the point T, and H the point B. The most reasonable solution to the question seems to be to draw a line in continuation of R^1 T^1, curving it out to reach the point H. The line R^1 T^1 H will then be a plan of R T B of the elevation. Lines dropped vertically from *c* and *d* of the elevation, intersecting this line at c^1 d^1, will then locate the desired points in

the plan. Next drop lines from h and k to the center line of the plan, as shown. Then h^1, c^1 and a^2 are three points through which a curve, elliptical in character, must be drawn, establishing a plan of the line $h\ a^1$ of the elevation. In the same manner a like curve drawn through k^1, d^1 and b^2 will answer as a plan of the line $k\ b^1$.

The points and curves in the right half of the plan are obtained by a similar process, which is all shown by the lines of projection and the reference letters.

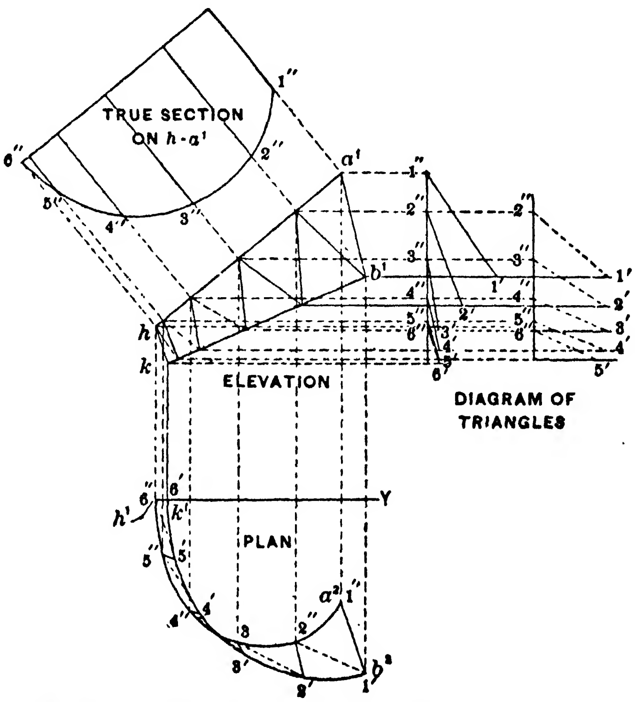


Fig. 93. Elevation, Plan and Section of Second Piece $k\ h\ a^1\ b^1$, in Left Side of Fig. 89, Showing Triangulation

Should it be desired the projection of all the curves now shown in the plan could be obtained upon the end elevation by a process similar to that just gone through in obtaining the plan, simplified, however, by the fact that no questions of design can there arise, the position of all important points having been already established in drawing the plan. Likewise the projections of the circles represented by the joint lines between A P and N M could be obtained upon both the plan and the end view by the method employed in obtaining the semi-ellipse $P^1\ T^1$ J from the line P T A. These operations, however, would only be valuable as a lesson in drawing, as they are in no way necessary to obtaining the patterns, though the reader is advised to do so inasmuch as this is a lesson in drawing.

In preparing drawings of the second case, shown in Fig. 88, the methods employed in the foregoing demonstration are equally applicable. The completed drawings of the same are given in Fig. 90, in which corresponding points in the several views are connected by the lines of projection. The conditions of the two cases are so nearly alike that the reader will have no difficulty in applying the demonstration given above to this case. The sketch shown in Fig. 88 differs from that in Fig. 87 principally in the fact that the two outlets are in line at the back, which gives a longer throat line to the smaller pipe than in the former case. The throat proper is confined to a quarter circle the center of which is at G, Fig. 90, as

in the former case, the line is then carried vertically to the point E. This keeps that part of the elbow from A to N a regular pieced elbow, as in the former case, and simply modifies the shapes of those pieces lying between A and the line E F. Of course the throat line could be made a continuous curve from E to M if desired, but at the expense of much more labor in obtaining the final pattern.

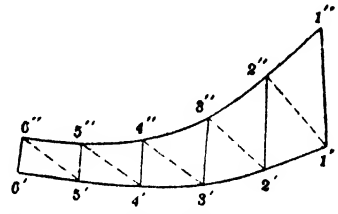


Fig. 94. Half Pattern of Piece Shown in Fig. 93.

The necessary drawings having been completed, it will be advisable before attempting to develop any of the patterns to make separate new drawings, each of which shall include the plan and elevation of one of the pieces, which shall be in all respects duplicates of the outlines already obtained, and placed conveniently near together, thus facilitating the subsequent operations by avoiding the confusion of lines which would result from performing them all upon the one elevation.

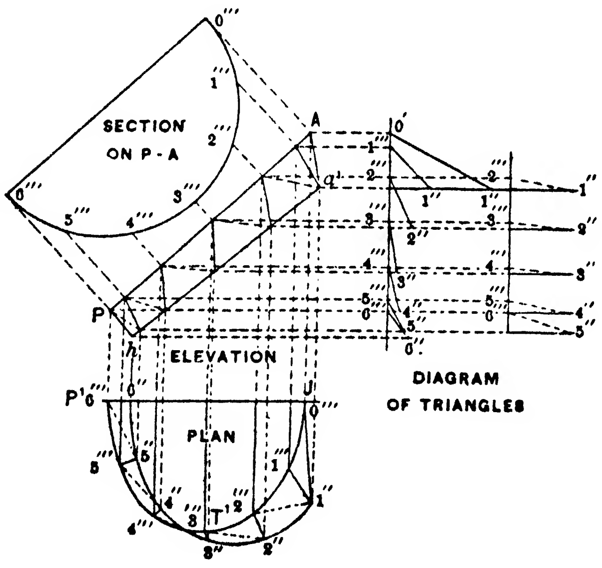


Fig. 95. Elevation, Plan and Section of Third Piece, h P A a^1, in Left Side of Fig. 89 Showing Triangulation

In Fig. 91 is shown a duplicate of the piece E k b^1 B of Fig. 89, there indicated by the same letters, below which is its plan traced from Fig. 89, in which E^1 H is a plan or true section on the line E B of the elevation and k^1 b^3 is a horizontal projection of the line k b as traced from the line bearing the same letters in Fig. 89. Each of these curves constituting the plan of the piece may now be divided into the same number of equal spaces of convenient size, and numbered correspondingly, as shown by the small figures. Points of like number must be connected by solid lines, and the four-sided figures thus produced must be subdivided diagonally by dotted lines, as shown. The triangulation thus produced may be seen to better advantage upon the elevation, the points upon the upper and lower bases being obtained in that view by projection from the corresponding points of the plan, all as shown by the vertical dotted lines.

The true lengths of the several solid and dotted lines thus obtained in both plan and elevation are to be obtained by the method usual in all similar operations—

that is, by considering them as the hypotenuses of triangles the altitudes of which are obtained from the elevation and the bases of which are these lines as they appear on the plan.

This operation is shown in the diagram of triangles at the right, in which the hights of the points in the vertical lines V W and X Y are obtained by projection from the elevation, while the horizontal distances between corresponding points are obtained by measurement from the plan; the hypotenuses being drawn give the true distances across the pattern, which is given in Fig. 92.

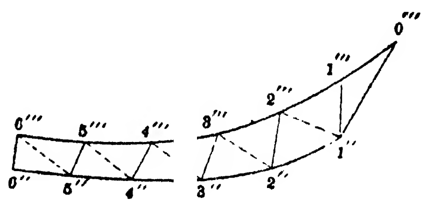


Fig. 96. Half Pattern of Piece Shown in Fig. 95

The lengths of the spaces upon the lower line of the pattern are obtained from E^1 H, the plan of the lower base of this piece. To obtain the lengths of the spaces upon the upper line of the pattern, however, a true section on $k\ b^1$ must be obtained as shown above, since it is evident that distances measured upon the oblique line are greater than the horizontal distances as given upon the plan. This section is obtained by the usual operation of raking from the line of the upper base as given in the plan, viz.: Draw lines from each of the points in $k\ b^1$ at right angles to the same, intersecting the line $6'\ Z^1$ of the section which is drawn parallel to $k\ b^1$. The distances of the several points in the developed curve from the line $6'\ Z^1$ are the same as those of corresponding numbers in the plan from the line $6'$ Z.

In Fig. 93 is shown the duplicate drawing of the second piece of the left portion of the elbow with its plan, diagram of triangles and the true section of its upper base. In drawing its plan, $k^1\ b^2$, the line of its lower base may be traced and transferred from Fig. 91, with its points as there used, instead of being obtained from the original plan. The true section obtained in Fig. 91 becomes the true profile of the lower base of this piece, therefore the stretchout of the lower side of its pattern, shown in Fig. 94, may be taken from the true section in Fig. 91. The points in $k^1\ b^2$ from which this section was derived are thus located at once in the plan in Fig. 93 by the transferring above alluded to and form the basis of the triangulation. The subsequent work of developing the pattern of this piece is exactly similar to that employed in obtaining the first piece.

In Figs. 95 and 96 are shown the necessary drawings and pattern of the third piece. The true section obtained in Fig. 93 becomes the true lower base of this piece, while the true upper base is a semicircle the diameter of which is A P of Fig 89. While the true projection of this semicircle in the plan, as shown by $P^1\ T^1$ J of Fig. 89, is according to geometrical rules a perfect semi-ellipse, it is better to obtain the same in Fig. 95 by the operation of raking, so dividing the same that the

points and spaces used may also be used in connection with those of the lower base $h\ a^1$ for the purpose of triangulation. It will be noticed that one more space has been taken in the upper base of this piece than in the lower on account of its greater length, and that the triangles have been so arranged that the apexes of two come together at the point 1″. By this treatment the triangles so produced are more nearly equilateral, and can therefore be more accurately constructed in the operation of laying out the pattern than if they were very scalene.

SECTION III

(Pages 343-436)

LAYOUTS FOR VARIOUS SHEET METAL SHAPES

Practical Sheet Metal Work and Demonstrated Patterns

SCHEDULE FOR HAND MADE TINWARE

It would seem, perhaps, that the use of hand made tinware was practically obsolete, since it has become so largely replaced to-day by machine made stamped goods. And yet the fact that there is, and probably always will be, more or less demand for this class of goods, especially in jobbing shops and the more remote country shops, shows the importance of knowing something of the sizes and dimensions of these articles.

The advantage of the schedules in vogue before the advent of machine made goods lies in the fact that they were gotten up with a special view of working material to the best advantage with the least possible waste. Another consideration that would seem to make the publication of these old but reliable schedules both desirable and important is the fact that "old Father Time" is fast thinning out the ranks of the "all around mechanic," and the field will soon be left to our young men growing up in the trade. If they understand the old and well tried methods of getting out the work, they will become better and more thorough mechanics, and hence more serviceable to their employers.

Schedule of Dimensions of 1-Pint, 3-Pint and 2-Quart Tin Basins.

	Dimensions in inches.			
		Depth on	Diameter.	
Size	*Depth*	*Flare*	*Top*	*Bottom*
1-pint	2¼	2⅜	5¾	4⅛
3-pint	2½	2⅝	8	6⅜
2-quart	3 15/32	3⅝	8½	6¼

One-Pint Basin.—The body made of two pieces, out of 10×14 tin.

Three-Pint Basin.—The body made in three pieces, cut out of 10×14 tin. Two pieces cut out of the width of the sheet 10 inches, and one piece one-half the long way of the sheet, or 7 inches.

Two-Quart Basin.—The body made in two pieces, out of a 10×14 sheet of tin and cut lengthways of the sheet.

Schedule of Dimensions of 6-Quart and 10-Quart Milk Pans.

	Dimensions in inches.			
		Depth on	Diameter.	
Size	*Depth*	*Flare*	*Top*	*Bottom*
6-quart	$3\frac{13}{32}$	$3\frac{3}{4}$	$11\frac{3}{4}$	$8\frac{3}{4}$
10-quart	$3\frac{13}{32}$	$3\frac{3}{4}$	$14\frac{1}{2}$	11

Six-Quart Pans.—The sides, or body of pan, are of four pieces of equal size, three pieces out of a 10×14 sheet of tin, cut crossways, or 10 inches width of sheet.

Ten-Quart Pans.—The sides, or body, are in four pieces, two pieces crossways of the sheet and two pieces lengthways of the sheet.

Schedule of Dimensions of Small and Large Dish Pans

	Dimensions in inches.			
		Depth on	Diameter.	
Size	*Depth*	*Flare*	*Top*	*Bottom*
Small	$6\frac{1}{2}$	$6\frac{3}{4}$	14	10
Large	$7\frac{5}{8}$	8	18	13

Small Dish Pans.—The sides, or body, are made in five pieces of equal size out of 10×14 tin. Two pieces out of a sheet.

Large Dish Pans.—The body is made in four pieces of equal size, one piece out of a 10×14 sheet, cut lengthways of the sheet.

Schedule of Dimensions of 1-Quart and 2-Quart Dippers.

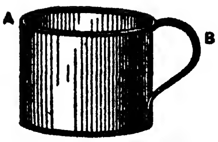
	Dimensions in inches.								
					Handles.				
							Size of Patterns.		
Size of Dipper.	*Depth*	*Depth on Flare.*	*Diameter Top*	*Diameter Bottom.*	*Top Diameter.*	*Bottom Diameter.*	*Length*	*Top Width.*	*Bottom Width.*
1-quart.	$3\frac{7}{8}$	4	6	$4\frac{1}{8}$	1	$\frac{3}{4}$	9	$3\frac{3}{8}$	$2\frac{1}{2}$
2-quart.	$4\frac{7}{8}$	5	$7\frac{1}{2}$	$5\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{1}{8}$	5	5	$3\frac{3}{4}$

One-Quart Dippers.—The body is made in two pieces of equal size, out of 10×14 tin, cut crossways of the sheet.

Two-Quart Dippers.—The body is made in two pieces of equal size, out of 12×12 tin.

PATTERNS FOR A DRINKING CUP

A



B

Fig. 1. A Tin Cup

There are many simple articles that can be made by the apprentice in the tin shop, with the ordinary tools. One of these is a plain drinking cup, such as is shown in Fig. 1. These are usually made from IC bright tin with a wire or hem edge at A. The bottom has a single edge and is soldered on the inside when hand made. Fig. 2 shows the three patterns for the cup. The pattern A, for the body, is cut on the squaring shears, of the required hight and in length equal to the circumference of the bottom, B. If the seam in the body is soldered, then only a single edge is necessary, as shown at *b*. If the seam is grooved, edges are allowed,

as shown at *a* and *b*. Should a wire or hem edge be allowed along the top of the cup, it should be notched at the corners, as shown. B shows the bottom with a single edge at *c*, while C D is the pattern for the handle, which is obtained by making C D equal to the length, and *d d* and *e e* equal to the top and bottom widths. The hem edges *f* and *f* are added. The body, A, is edged and wired, then rolled, the edge turned on the bottom B and then soldered to the body. The handle, C D, is then edged, formed to the required shape and soldered to the cup.

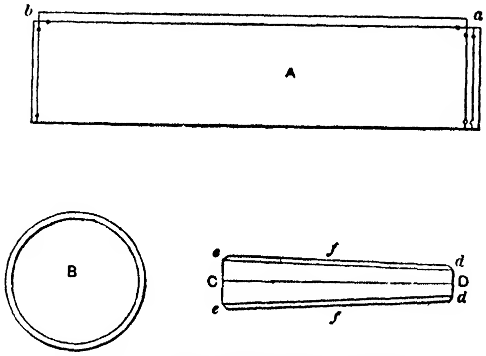


Fig. 2. The Patterns for the Cup

PATTERNS FOR REFRIGERATOR PAN

These pans can be made up in different sizes from No. 26 or 28 galvanized iron. A finished pan is shown in Fig. 3. The only difficulty in their construction is to obtain the pattern for the handles. In Fig. 4 a sectional view shows how the pan is constructed. B shows the bottom, with a single edge at C C slipped over the body and soldered on the inside. A A shows the wired edge, with the handles soldered or riveted at D and D. The pattern for the body is simply a straight strip of metal, to which allowance has been made for wiring. In length it is equal to the circumference of the bottom, allowing for seaming.

To obtain a true pattern for the handle, without which a lot of time is lost in trimming, proceed as is shown in Fig. 5. A B C shows a part elevation of the pan, a part plan of which is shown by D E, struck from the center F. Establish, at pleasure, the point 4″ in elevation, from which, at its proper angle and of the desired length, draw the line 4″ *b*. Extend 4″ *b* as 4″ 4. From 4 draw the perpendicular 4 *a*. With the desired radius, as 4 *a*, using *a* as center, describe the semicircle shown, which divide into equal spaces, shown from 1 to 4 to 1. Take a tracing of the profile 4 *a* and place it in plan on the center line F G, as shown by 4 *a*′. From points on profile and parallel to G F draw lines intersecting the body of the pan from 1′ to 4′. From these points erect vertical lines into the elevation, which intersect by lines drawn from similar numbered points in the profile A *a*, parallel to 4 4″, resulting in the intersections 1″, 2″, 3″ and 4″. Through these trace the miter line shown. Draw a line from *b* to 1″, which completes the side

view of the handle. From 1″, at right angles to 4″ b, draw 1″ c, on which line the profile 1 4 1 a is a section.

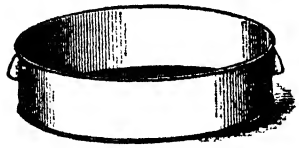


Fig. 3. Perspective View of Refrigerator Pan

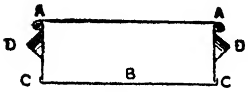


Fig. 4. Sectional View

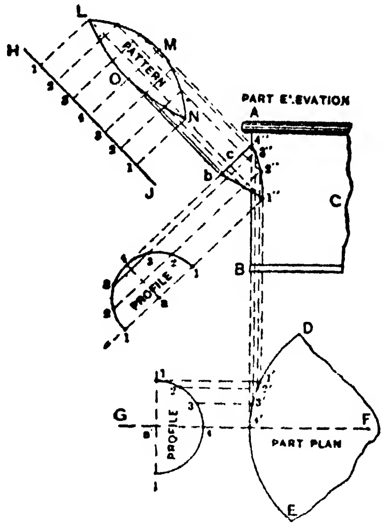


Fig. 5. Determining Pattern for Handle

For the pattern draw J H at right angles to 4 4″, upon which place the stretch-out of the profile 4 a. From these small figures, at right angles to H J, draw lines, which intersect by lines drawn at right angles to 4 4″ from similar points of intersections on b 1″ 4″. Trace a line through the points thus obtained, as L M N O, which is the desired pattern. Allow edges for riveting or soldering.

PATTERN FOR AN APPLE CORER

A useful little article that can be made from scrap tin, with all seams and joints soldered, is an apple corer. The full size dimensions and method of obtaining the pattern for the corer are shown in Fig. 6 and Fig. 7, in which A B C D is the side view of the corer, soldered to the handle E at the top, with an opening on the line C D, which forms the blade which cuts into the apple, while the opening 1′ 3′ 1″ allows the core to be taken out. The section through the corer is shown by F in plan. H I J K L shows the front view, K representing the circular blade, M the opening and N the joint. The round disks G and G at the ends of the handle are slightly convex, and assume that shape when using the hollow punch in punching the disks.

To obtain the pattern for the corer proceed as follows: Divide the half plan F into an equal number of spaces, as shown by the small figures 1 to 5. Parallel

to B C and from these small figures draw lines intersecting the blade line D C, the core opening at 1′, 2′, 3′, 2″ and 1″, and the handle E, as shown. Now at right angles to B C draw any line, as O P, upon which place twice the number of

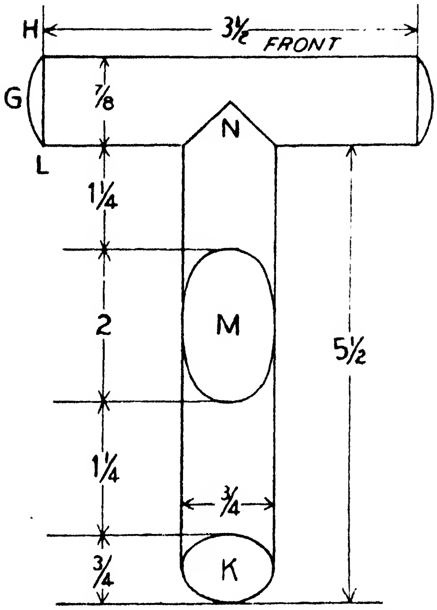


Fig. 6. Corer with Dimensions

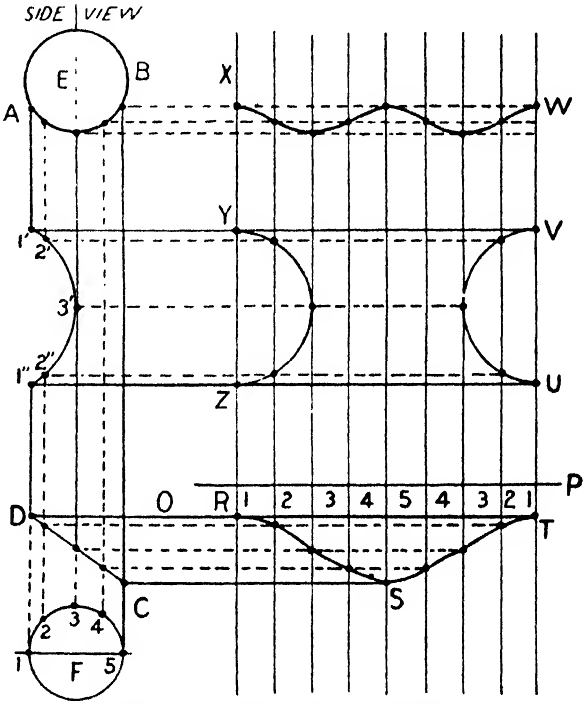


Fig. 7. Obtaining the Pattern

spaces contained in the half plan F, as shown by the small figures 1 to 5 to 1 on O P. Through these intersections and at right angles to O P draw lines indefinitely, as shown, which intersect with lines drawn from points of intersections on D C, 1′ 2′ 3′ 2″ 1″, and on A B having similar numbers, as shown in the pattern. A line traced through points of intersection thus obtained, as shown by R S T U V W X Y Z, will be the pattern for the corer. The pattern for the handle is not shown, as that simply consists of a tube as long as from H to I in front, with a diameter equal to E in side view, having the convex disks soldered on same to close the ends.

PATTERN FOR SCALE SCOOP

A finished view of a scale scoop is shown in Fig. 8, where the top edge is wired and the joint either seamed or soldered. While the pattern can be obtained by the cone or radial line method, a simpler rule is shown in Fig. 9, by which the pattern is developed by means of the parallel line method.

First draw the elevation of the scoop, as shown by A B C D. In practice one-half elevation is all that is required. From the point B, at right angles to D C, draw the line B E, on which line a true section must be obtained, as follows: Extend the line D C as D F. Parallel to D F, and from B draw the line B G. At any point, as H, at right angles to B G, draw the line H I, which represents the depth of the scoop. At pleasure establish the width of the scoop at the top, as shown by K and L. Draw a line from K to I, which bisect and obtain the point T. From T, at right angles to K I, draw a line intersecting the center line H I at J. With J as center and J K as radius describe the arc K I L, which represents the true section on the line B E in the elevation.

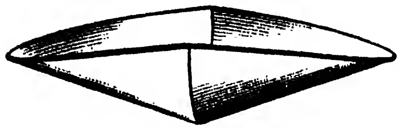


Fig. 8. Perspective View

Divide the section into equal parts, as shown by the small figures 1 to 4 to 1, through which, parallel to G B, draw lines into the elevation, intersecting the lines B C and B D at points 1 to 4, as shown. Now, at right angles to D C draw the stretchout line M N, upon which place the stretchout of the true section, as shown by points 1 to 4 to 1 on M N; through which, at right angles to M N, draw lines, which intersect with lines drawn at right angles to D C from similar numbered intersections on B C and C D. A line traced through the points thus obtained, as shown by M O N P, will be the half pattern of the scale scoop. Allowance must be made for wiring and seaming.

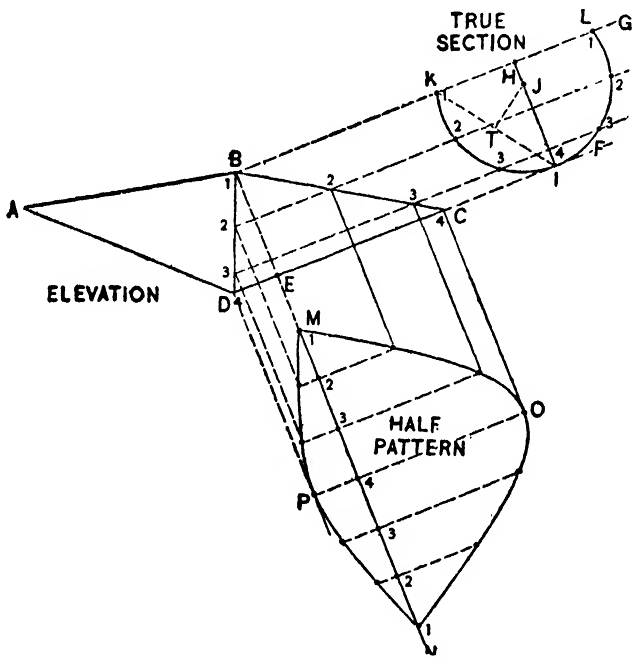


Fig. 9. Elevation, Section and Pattern

PATTERNS FOR HAND SCOOP

A finished or perspective view of a grocer's hand scoop, which is a piece of tinware usually made by hand in the tin shop, is shown herewith in Fig. 10.

When carefully designed it presents a neat appearance, especially when made of bright tin or polished brass. The scoop contains three patterns, shown by A, B and C. The body, A, is seamed at *a*; the flat bottom in the back of the scoop is seamed to the body at *b*, and a small button is seamed to the handle B at *c*. The handle could, if so desired, be made tapering with very little additional labor in the developing of the pattern.

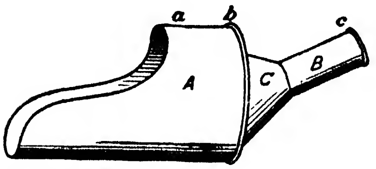


Fig. 10. Perspective View of Hand Scoop

The method of laying out the patterns is shown in Fig. 11, in which A B C D represents the side view of the scoop, care being taken to draw a graceful curve, A D. In its proper position draw the section or diameter the scoop is to have, as shown by E F G H, which divide into equal spaces, as shown by the small figures 1 to 7 on either side. Through these small figures, parallel to D C, draw lines intersecting the curve A D, as shown. For the pattern for the scoop, in line with B C draw the line C J, upon which place the stretchout of the section E F G H, as shown by the small figures 1′ to 7′ to 1′ on C J. Through these small figures, at right angles to C J,

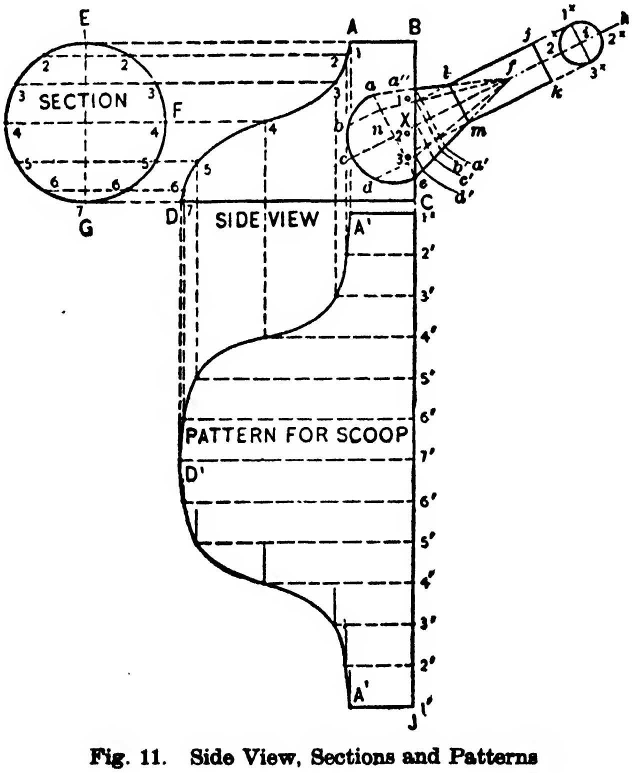


Fig. 11. Side View, Sections and Patterns

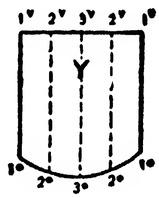


Fig. 12. Pattern for Handle

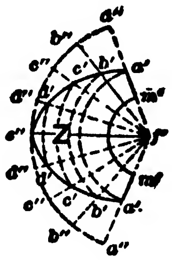


Fig. 13. Pattern for Conical Boss

draw lines, as shown, which intersect with lines drawn from similar numbered points on A D at right angles to D C. Trace a line through these points, as

shown. Then will 1′ A^1 D^1 A^1 1′ be the net pattern for the scoop. The pattern for the back of the scoop B C is shown by the section E F G H, to which laps must be allowed for seaming.

For the pattern for the handle, B in Fig. 10, proceed as is shown in Fig. 11. First locate the point X on the line B C, where the center of the handle will strike, and, at its proper angle, draw a line through X, as shown by *c h*. With any point, as *i*, as center, on the line *c h*, draw the profile of the handle, as shown by 1^x 2^x 3^x 2^x. From 1^x and 3^x, parallel to the center line *h c*, draw the lines 1^x 1° and 3^x 3°, intersecting the line B C at 1° and 3°. Establish the length of the handle, as *j k*, which line draw at right angles to *h c*. Now divide the profile *i* into an equal number of spaces, as shown by the small figures 1^x 2^x 3^x 2^x. (In practice more spaces must be used.) Through these small figures, parallel to the lines of the handle, draw lines intersecting the line B C at 1°, 2° and 3°.

For the pattern, draw any horizontal line, as 1^v 1^v in diagram Y, Fig. 12, upon which place the stretchout of the profile *i* of the handle, as shown by similar numbers on 1^v 1^v. From these points, at right angles to 1^v 1^v, draw lines indefinitely, as shown. Measuring from the line *j k* in the side view, Fig. 11, take the various lengths to 1°, 2° and 3°, and place them on lines having similar numbers in diagram Y, measuring from the line 1^v 1^v, thus obtaining the intersections 1° 2° 3° 2° 1°. A line traced through the points thus obtained, as shown by Y, will be the net pattern for the handle.

For the pattern for the conical boss C in Fig. 10 proceed as is shown in Fig. 11. First locate the top of the boss *l m* in the side view, which is drawn at right angles to the center line *h c*. Then locate the point *e* on B C at pleasure, and extend the line *e m* until it meets the center line at *f*. From *f* draw a line through *l* intersecting the line B C at A″, and meeting the line drawn from *e* at right angles to the center line *h c* at *a*. Then will *a e m l* represent a frustum of a right cone intersected by the line *e a″*. Using *n*, the intersection between the line *e a* and *h c*, as center and *n a* or *n e* as radius, describe the arc *e c a*, which divide into equal spaces, as shown by the small letters *a b c d e*, from which points, at right angles to *a e*, draw lines intersecting the base line *a e*, as shown. From the intersections on *a e* draw lines to the apex *f* intersecting the line B C, as shown by the small dots, from which, at right angles to *h c*, draw lines intersecting the side of the cone *m e* at *a′*, *b′*, *c′*, *d′* and *e*.

For the pattern take *f e* as radius and *f′* in diagram Z, Fig. 13, as center, and describe the arc *a″ a″* upon which, starting from *a″*, lay off the stretchout of twice the number of spaces contained in the semicircle *a c e* in the side view, Fig. 11, as

shown by similar letters on the arc $a'' \; a''$ in diagram Z, Fig. 13. From these points draw lines to the apex f', which intersect with arcs struck from f' as center and radii equal to $f\,a'$, b', c', d' and e, thus obtaining intersections having similar letters in diagram Z. With $f\,m$ in the side view, Fig. 11, as radius, and f' in Z, Fig. 13, as center, describe the arc $m' \; m'$ intersecting the radial lines $a'' \; f''$ at m' on either side. Then will $m' \; a' \; e'' \; a' \; m'$ be the net pattern for the conical boss.

An article, known as a "Thumb Scoop," of small size used generally to handle such stuff as spices, and which has just an ordinary tin drinking cup handle, can be laid out by the above principles.

PATTERNS FOR CLOTHES SPRINKLER

In Fig. 14 is shown a finished view of a clothes sprinkler, used to dampen clothes before ironing. This sprinkler can be made from IX tin about 4 in. in diameter and about 5 in. high. It is filled with water by opening the screw top A; which is purchased, made from zinc.

A

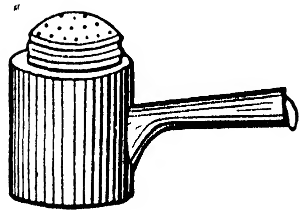


Fig. 14. Finished Article

The method of construction and of obtaining the various patterns is shown in Fig. 15, in which A shows the body of the screw top, edged and soldered to the body of the can at C, or if desired, it may be double seamed and soldered; while B shows the sprinkler top which can be unscrewed from the body A. The bottom is edged and soldered to the body at D. The pattern for the body is simply a rectangular piece the length of which is equal to the circumference of the bottom and of a width equal to the hight C D.

The pattern for the handle E is obtained by extending its sides until they intersect at H, which becomes the center point from which to strike the pattern, using as radii H F and H T and describing the pattern J K L M, the girth of the circle G being placed along the arc J K, allowing a lap at e for soldering.

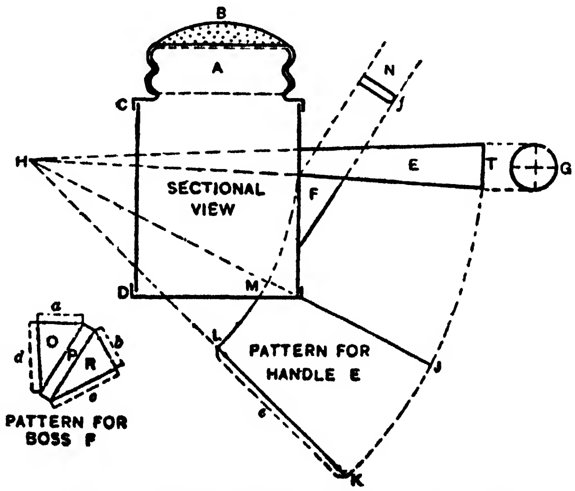


Fig. 15. Vertical Section Through Sprinkler

While the intersection between the handle E and body M presents a problem of a cone intersecting a cylinder, it has been assumed that the handle or cone E is intersected by the plane F, which answers for all practical purposes, when the diameter of the handle is small and that of the body large. The boss F, the section of which is shown at N, is developed by taking a reproduction of F and placing it as shown at O. The distance P is now placed perpendicular to O equal to the girth of the curve *f* in N, and then O traced to the opposite side, as indicated by R. Edges are allowed for soldering purposes as shown by *a b c* and *d*. A button is edged or soldered to the handle at T.

PATTERN FOR STRAINER

For a strainer to fit in the bottom of a tank, in Fig. 16 is shown the article, in which A B is the part bottom of the tank and 5′ 1 5 the plan view of the strainer. A^1 B^1 in front elevation shows the horizontal plane of A B in plan,

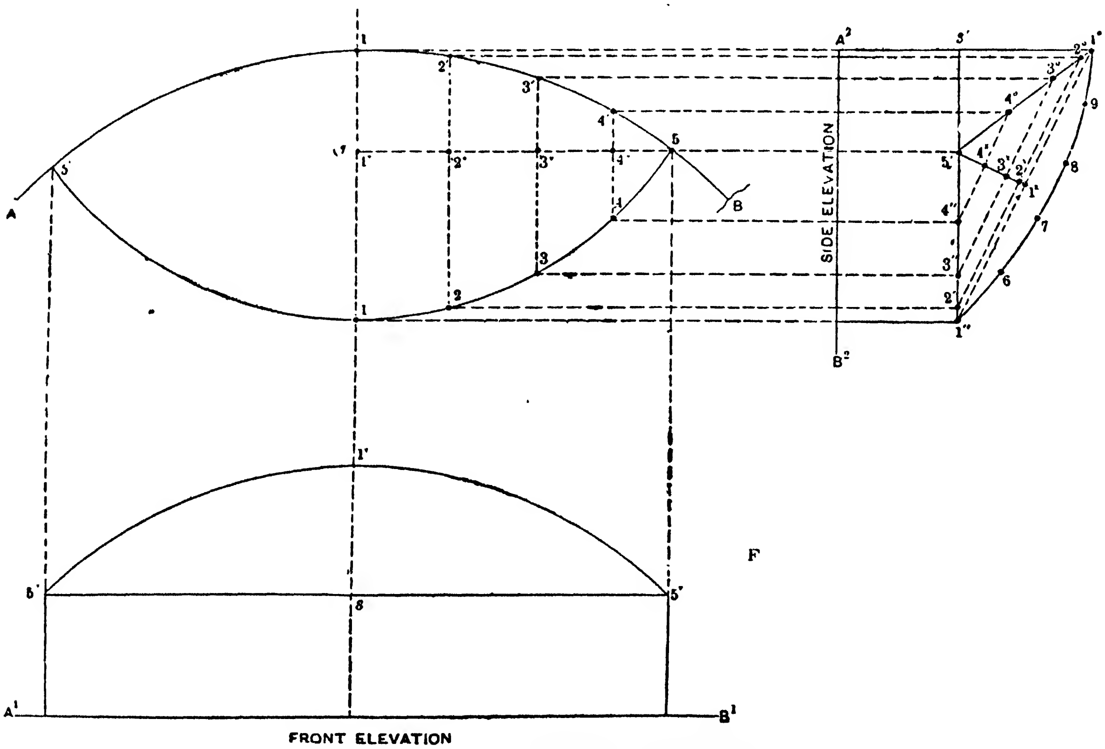


Fig. 16. Plan and Elevation of Strainer

while 5^v 5^v in elevation shows the horizontal plane of 5′ 5 in plan. 1^v in elevation shows the rise of the strainer at 1′ in plan. In the side elevation A^2 B^2 is the

plane on A B in plan and s $1''$ the plane on $5'$ 5 in plan. s' 1° is equal to s 1^v in front elevation. The strainer must be "raised" to have the shape as shown by 5^v 1^v 5^v in front and 1° $1''$ in side. In obtaining the pattern for that part of the strainer shown by A^1 B^1 5^v 5^v in front elevation, all that is required is to cut a strip of metal with a hight equal to A^1 5^v and a length equal to $5'$ 1 5 in plan.

In obtaining the pattern for the top or raised portion, assume that 1° $1''$ in side elevation is straight, and then when the pattern is developed add the difference between the straight line 1° $1''$ and the curved line 1° 8 $1''$, as shown between 1° and X in Fig. 18. For the pattern proceed as follows: As both halves of the strainer are symmetrical, divide the curve of the strainer shown from 1 to 5 in plan in Fig. 16, as shown by 1, 2, 3, 4 and 5. From these points parallel to the center line draw lines intersecting the curve of the tank at $1'$, $2'$, $3'$ and $4'$. From 5, at right angles to 1 $1'$ draw the line 5 r intersecting the previously drawn lines at 1^v, 2^v, 3^v and 4^v. From the various points 1 to 5 parallel to r 5 draw lines cutting the line s' $1''$ in side elevation at $1''$, $2''$, $3''$, $4''$ and $5''$, from which points parallel to the line drawn from $1''$ to 1° draw lines indefinitely until they intersect lines drawn from the intersections $1'$ $2'$, $3'$ and $4'$ in plan, resulting in the intersections 1°, 2°, 3°, 4° and $5''$ in side elevation. A line traced through these points shows the line of joint between the strainer and side of tank.

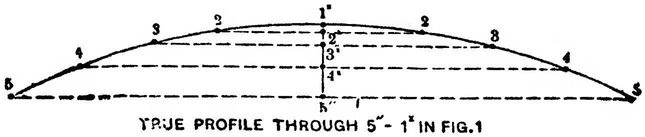


Fig. 17. Method of Finding True Profile

From $5''$, at right angles to 1° $1''$, draw the line $5''$ 1^x intersecting lines at 2^x, 3^x and 4^x. Take the distance of 1^x $5''$ with the various intersections on same and place it in a vertical position, as shown by similar numbers in Fig. 17, through which draw horizontal lines indefinitely, as shown. Measuring from the line $1'$ 1 in plan in Fig. 16, take the various distances to 2^v, 3^v, 4^v and 5 and place them on lines having similar numbers in Fig. 17, measuring on either side of the line 1^x $5''$. A line traced through points thus obtained, as shown from 5 to 1^x to 5, will be the true profile through $5''$ 1^x in side elevation in Fig. 16.

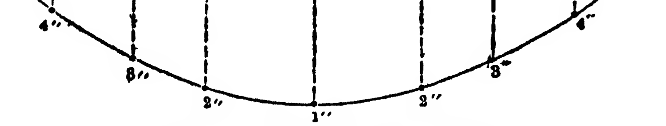


Fig. 18. Pattern for the Strainer

In Fig. 18 draw any horizontal line, as 5 5, upon which place the stretchout of 5 1^x 5 in Fig. 17, as shown by similar figures in Fig. 18, through which points draw vertical lines as shown. Measuring from the line 5″ 1^x in side elevation in Fig. 16, take the various distances to points 1″ to 5″ and to points 1° to 4° and place them in Fig. 18 on either side of the line 5 5, as shown by similar figures. Trace a line through points thus obtained, then will 5 1″ 5 1° 5 be the pattern, if the strainer was straight on the top, as shown by the line 1° 1″ in side elevation in Fig. 16.

As the cut shown from 5 to 1″ to 5 in Fig. 18 is the correct cut to fit on 5′ 1 5 in plan in Fig. 16, take the girth of the curve in side elevation shown by the small figures 1″ to 6 to 7 to 8 to 9 to 1° and place it from 1″ to X in Fig. 18, and draw the curved line 5 to X to 5. Then 5 X 5 1″ 5 is the desired pattern, which must be raised to the shape shown by 5′ 1 5 in plan in Fig. 16 and the curve 1° 1″ in the side elevation.

PATTERNS FOR A SCALE SCOOP AND STAND

In the lower left-hand corner of the diagram, Fig. 19, is an elevation drawn to scale giving dimensions of a scale scoop 13 in. wide and its stand. The problem is to assume that the scoop must be made in two parts with a seam on the line C D. It then becomes self-evident that the half portion of the scoop is a part of a body of, say, a cylindrical surface, and a section of it may be taken on the line A B perpendicular to the elements of the cylindrical surface. The top lines and the line C D are assumed as the edge lines of planes cutting this surface. To term the surface cylindrical is not to limit it to a cylinder as commonly understood, with circular base, but as a surface generated by a straight line moving always parallel to itself.

The half portion of the scoop is reproduced full size, as delineated in the lower half of the diagram, with the line A B in a vertical position to facilitate development. As the process is governed by certain dimensions, the section on A B cannot be granted as a part of a cylinder with a circular base or cross section, but an arbitrary section is drawn to the left of the scoop and adhering to the width given, the depth now being governed by the line A B, as shown. This is one-half of the section, the full section not being necessary.

This section is divided into convenient spaces, and lines drawn to the line C D and to the top line of scoop; in other words, the edges of the cutting planes already mentioned. Continuing the line A B as a stretchout line, the girth of the

section is placed thereon; the usual lines drawn through the points on this line and intersected by lines from the elevation, all as indicated. A line traced through the points of intersection is the desired one-half pattern.

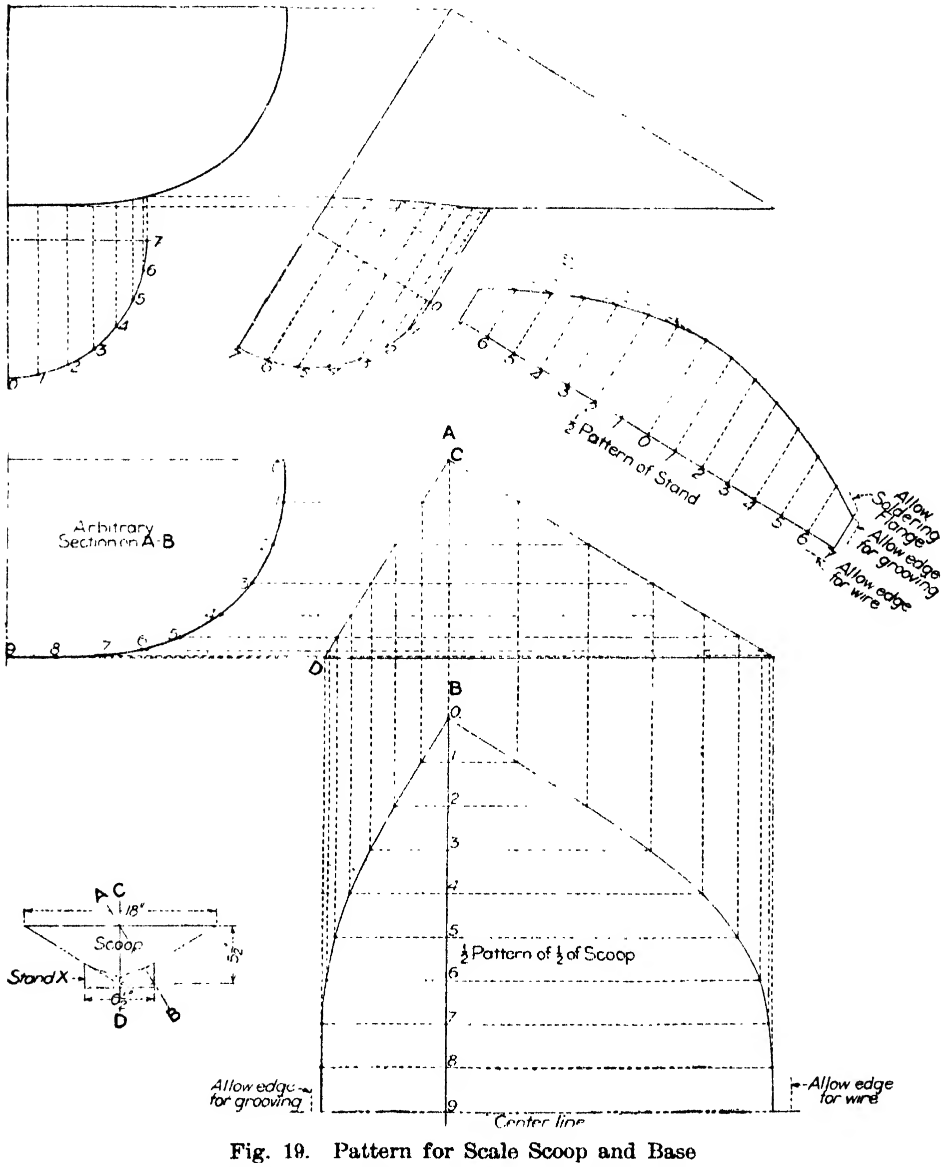


Fig. 19. Pattern for Scale Scoop and Base

It was presumed that the stand should be a cylinder, as the customary platform of a scale is round. The cylinder is, therefore, made of a size large enough to insure stability to the scoop when loaded, and at the same time not too big to slip over, instead of resting on the scales platform. A reproduction is made of the half elevation of the scoop and the section in its relative position. The elevation is placed with the top line horizontal, which allows using the T-square to develop miter line

and pattern, but to economize space and for appearance it is turned in the engraving, as shown at the top of diagram.

The intersection of the stand with the scoop, or the miter line of the cylinder, is developed by drawing a quarter circle of the stand under the section of the scoop; the center line of this quarter circle being coincident with that of the center line of the section. This quarter section is divided into equal parts and lines projected to the section and from there to the elevation, to be, in turn, intersected by lines drawn from a quarter circle placed in proper position under the elevation, as shown, or as called for by the small scale drawing.

As these points of intersection are the miter line, so to speak, a stretchout of one-half the stand is drawn, as shown by 7 to 0 to 7, and the customary measuring lines intersected by lines from the miter line, resulting in one-half the pattern of the stand.

PATTERN FOR A SAND SPRINKLER

A sand sprinkler, such as is used by painters to imitate stone by sprinkling sand on painted work, and which can be made by the tinner from tin plate or zinc, is shown herewith in Fig. 20. In this illustration A represents the body, B the perforated sprinkler, C C a zinc can screw, which may be bought from dealers in tinners' trimmings, and D a conical boss, which makes rigid the handle E, onto which the button F is soldered. In Fig. 21 is given the method of construction and the location of the joints, the cut being lettered to correspond with Fig. 20.

The method of laying out the patterns is shown in Fig. 22. First draw the side elevation of the article, in which A B C D shows the body, E the zinc screw, F G H I the handle and J L M K the boss. For the pattern for the body use E as center and describe the half section through the body, as 1 3 5, which divide into equal parts, as shown by the small figures 1 2 3 4 5. Through these points, parallel to A B, draw lines intersecting the face line A D. In line with B C draw the line C P, upon which place twice the number of spaces contained in 1 3 5, as shown from 5 to 1 to 5 on C P. At right angles to C P and through the small figures draw lines, which intersect by lines drawn at right angles to A B from similar intersections on A D. Trace a line through the points thus obtained; then will S R 5 5 be the pattern for the body.

For the pattern for the face, shown in elevation by A D, draw lines at right angles to and from the various intersections on A D, as shown. Parallel to A

D draw N O. Measuring in every instance from the line B C, take the various distances to points 2, 3 and 4 on the curve 1 3 5 and place them on corresponding lines, measuring in each instance from the line N O on both sides, thus obtaining the points 1′, 2′, 3′, 4′ and 5′. Through these intersections trace an ellipse, as shown, in which punch the required holes.

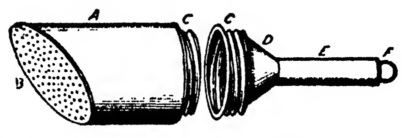


Fig. 20 Perspective View of Finished Article

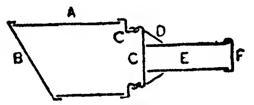


Fig. 21. Showing the Location of the Joints

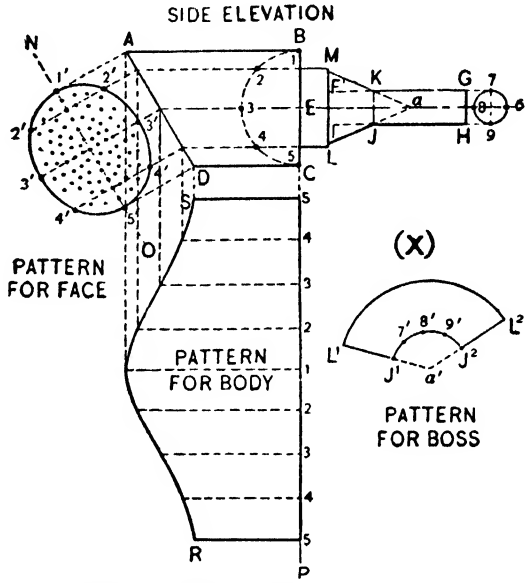


Fig. 22. Side Elevation and Patterns

The pattern for the handle F G H I will be as long as F G, and as wide as the circumference of the section 6 7 8 9. The pattern for the button G H is shown by 6 7 8 9. For the pattern for the conical boss, extend the lines L J and M K until they intersect the center line at *a*. Then, with radii equal to *a* J and *a* L, and with *a*′ in (X) as center, describe the arcs J^1 J^2 and L^1 L^2. From L^1 draw a line to the center *a*′, intersecting the inner arc at J^1. Starting from J^1, lay off the stretchout of 6 7 8 9 in side elevation, as shown by J^1 7′ 8′ 9′ J^2 on the arc J^1 J^2 in (X). Draw a line from *a*′ through J^2 intersecting the outer arc at L^2. Then will L^1 L^2 J^2 J^1 be the pattern for the conical boss. The parts are thus all obtained, and all that now remains to be done is to put them together and solder the joints.

By making the handle tapering a better assurance is made of a firm hold for the hand of the operator. This handle would be simply the frustum of a cone and laid out accordingly, the wide end being at G H of Fig. 22, and the same width as now shown is to be maintained at K J, so that the boss as here given would do for this kind of a handle.

PATTERNS FOR FLOUR SIFTER

In Fig. 23 is shown a finished view of a flour sifter, usually made from IC bright tin plate. The handle A, which is fastened to the body, is further strengthened by the conical boss B. C shows the wire handle which operates the beaters when the flour is to be sifted through the wire cloth sack on the inside of the body. Knowing the size of the sifter, first draw the elevation of the body of the sifter, as shown by A B C D in Fig. 24. Directly below it, in its proper position, draw the plan, as shown by E F G H. Midway between B and C in the elevation draw the handle I J, shown in plan by K L. Now draw M N in elevation, which represents the wire handle, made from ⅛-inch thick wire, which passes through the button on the end of the handle and through the two sides of the body, as shown. The wire handle is shown in plan by O E, and is fastened in position by the washers at *a* and *b*. A small knob fastened to the end of the wire handle is shown at *f*, while P shows the button double seamed to the tin handle at *c*, and R S the conical boss between the handle and the body.

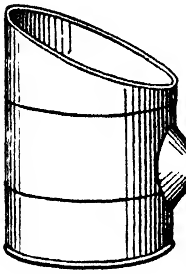


Fig. 23. Perspective View of Flour Sifter

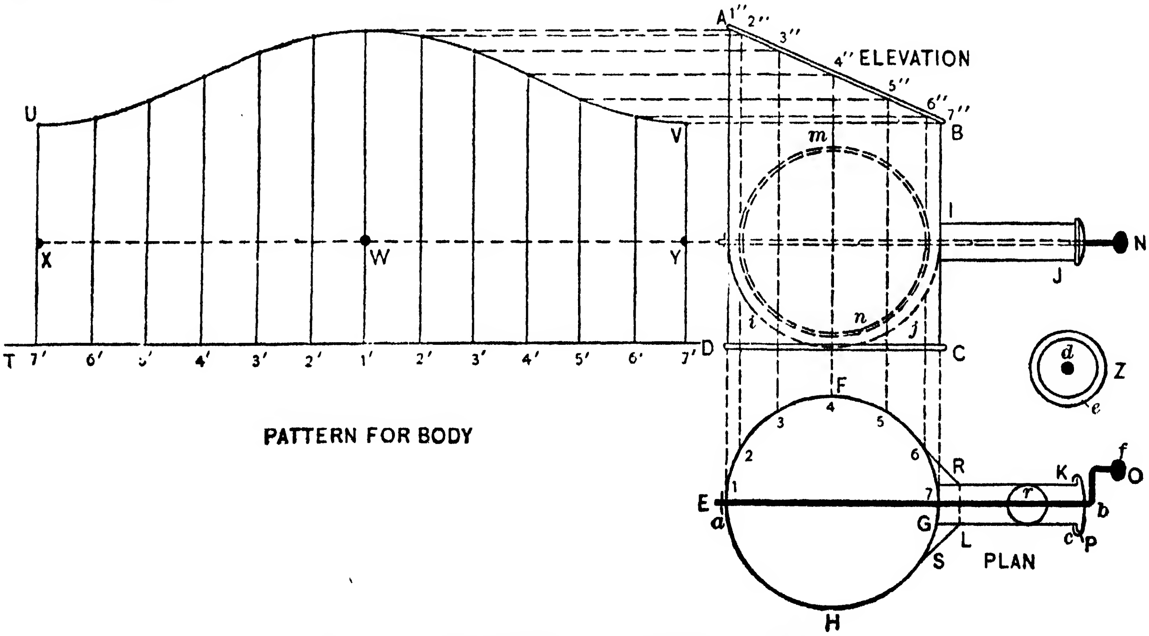


Fig. 24. Plan, Elevation, and Pattern for Body

As both halves of the body are symmetrical, divide the half plan E F G into an equal number of spaces, as shown by the small figures 1 to 7, from which erect vertical lines intersecting the top and bottom of the body in elevation, as shown.

In line with C D draw the line D T, upon which place twice the number of spaces contained in the half plan, as shown by similar figures on D T. At right angles to D T and from these small figures draw lines, which intersect with lines drawn from similar numbers on A B at right angles to A D. Trace a line through the points thus obtained. Then will U V D T be the pattern for the body of the sifter. It will be noticed that the pattern is obtained below and above the wire lines on top and bottom of the body respectively, and for that reason allowance must be made to the net pattern shown. The small dots X, W, Y represent small holes to be punched into the pattern to admit the wire handle N M and are obtained by projecting a line from M, intersecting the center and ends of the pattern as shown.

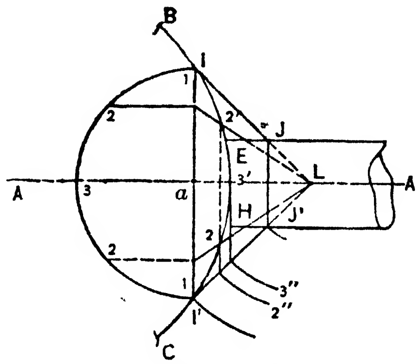


Fig. 25. Enlarged View of Boss

While the pattern for the handle K L in plan or I J in elevation presents a problem of two cylinders of unequal diameters intersecting each other at a right angle, assume that 7 G in plan is a flat surface and make the pattern in length equal to K 7 and in width equal to the circumference of the circle *r*, to which laps must be allowed for soldering. This pattern will answer for all practical purposes where the body is of so large, and the hand of so small, a diameter.

The pattern for the button P is shown at Z, *d* representing the hole punched to admit the wire handle, and *e* the edge to the double seam on the handle K L at *c*. For the pattern for the conical boss, R S, joining the round body of the sifter, proceed as is shown in Fig. 25, which is an enlarged view to clearly show each step taken. First draw the center line A A^1, and from A as center draw a portion of the body, as shown by B C. Then draw a portion of the handle E F G H and establish at pleasure the pitch at the boss I J and I^1 J^1. Extend these lines, intersecting the center line A A^1 at L. Draw a line from I to I^1, intersecting the center line at *a*. Using *a* as center and *a* I as radius, describe the half-section of the boss on the line I I^1, as shown by 1 3 1. Divide this half-section into equal spaces, as shown by the small figures 1, 2, 3, 2, 1, from which points, at right angles to 1 1, draw lines intersecting the base lines 1 1, as shown. From these points draw lines to the apex L, intersecting the body of the sifter B C at 1, 2′, 3′, 2′, 1. From these intersections, at right angles to the center line A A^1, draw lines intersecting the side of the boss at 1 2″ 3″. Now, with radius equal to L I, and L in Fig. 26 as center, describe the arc 1 1‴, upon which place the stretchout of

twice the number of spaces contained in the half section 1 3 1 in Fig. 25, as shown; by similar number on $1\ 1'''$ in Fig. 26. From these points draw radial lines to the center L, as shown. With radii equal to $L\ 2''$ and $L\ 3''$ in Fig. 25, and with L in Fig. 26 as center, draw arcs intersecting radial lines having similar numbers, as

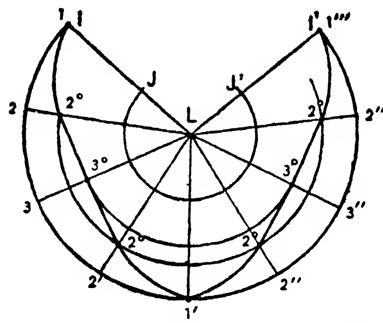


Fig. 26. Pattern for Conical Boss

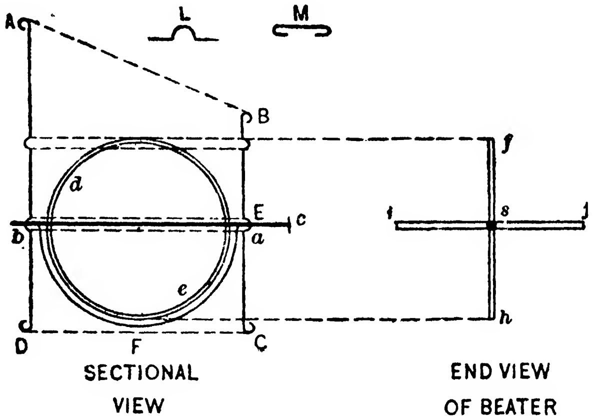


Fig. 27. End and Sectional Views

shown by the intersections 2°, 3°, 2°, 2°, 3°, 2°. In a similar manner, with radius equal to $L\ J^1$ in Fig. 25 and L in Fig. 26 as center, draw the arc $J\ J^1$, intersecting the radial lines drawn from 1 and $1'''$. Trace a line through the points thus obtained; then will $I\ 1'\ I^1\ J^1\ J$ be the pattern for the conical boss.

In Fig. 27 is shown the construction of the beater and wire cloth sack. A B C D represents the sectional view of the body with a bead turned out at D and E. The bead E should be placed at a distance from the bottom equal to the half diameter of the body. A circle of fine wire cloth is now cut equal in diameter to the stretchout of the half circle *b* F *a*, and then formed into the shape of a half sphere with an edge turned out slightly at the top, as shown at *a* and *b*, and tacked with solder around the bead E. Two strips of tin are now edged or beaded, as shown at M or L respectively (which is full size) and equal in length to the circumference of the circle *d e* (which is slightly smaller than the half sphere F, to allow it to turn easily), and rolled up and soldered. Then the two rings are joined together at right angles to each other, as shown in the end view of beater at *h f* and *i j*. A hole is punched through the center, as shown at *s*, to admit the wire handle. The ring beaters are now placed in the body, as shown by *d e*, and the handle *c* passed through the tin handle, body and rings. The rings are now soldered firmly to the tinned wire and the washers soldered to the handle on the outside, the beater then being ready for use. If the sifter is of large size, three or four rings can be used for the beater.

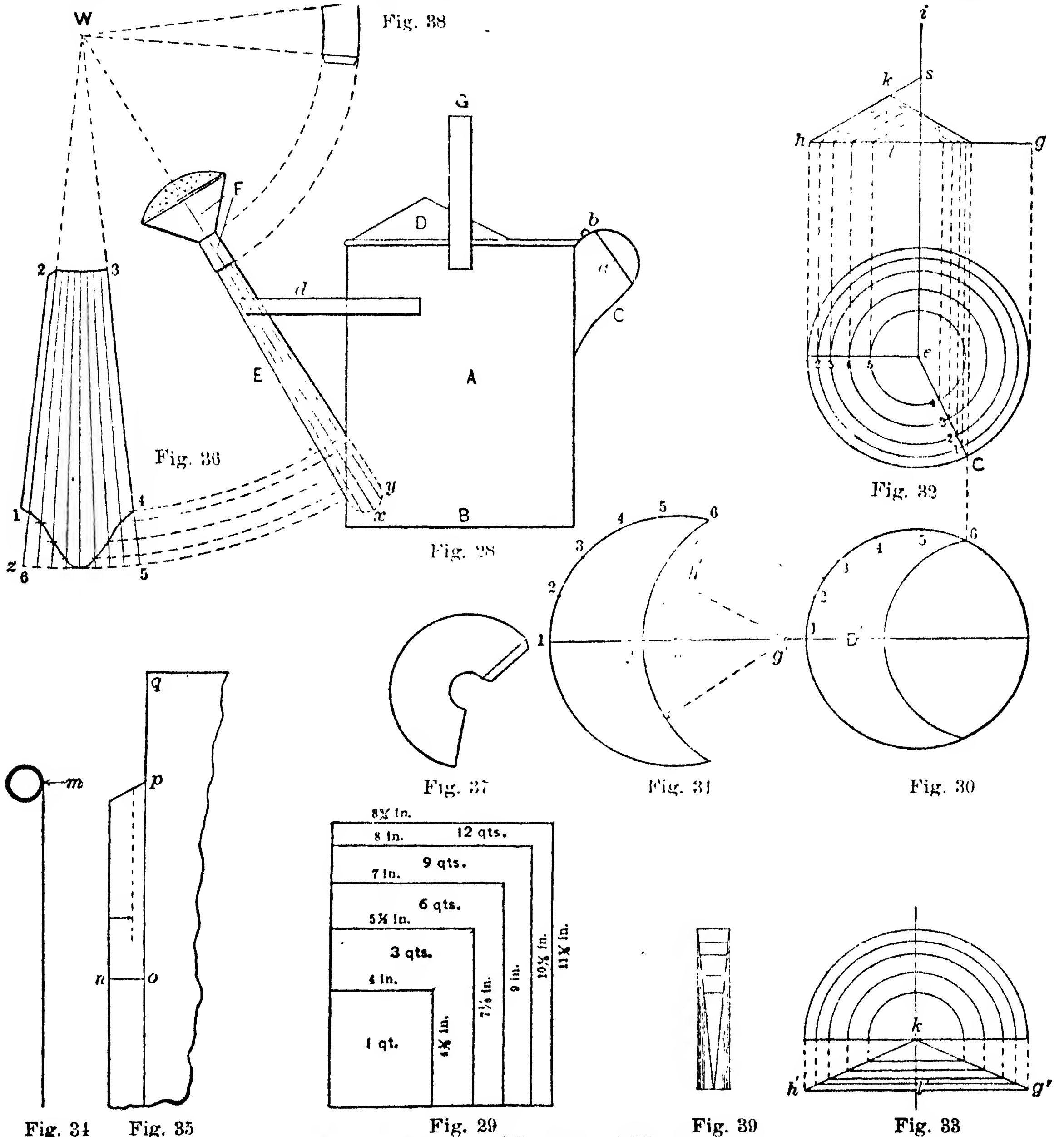
WATERING POTS, PROPORTIONS AND PATTERNS

In Fig. 28 a watering pot is shown composed of various parts. A shows the body of the watering pot, B the bottom, C the rear handle, D the crescent shape water guard, E the spout, F the sprinkler, G the bail or handle on top, *a* is the boss in rear handle, *d* is the brace, one on each side of the spout E used on the large sizes, from 6 to 12 quarts, for strengthening the connection of the spout E with the body of the watering pot.

Before a watering pot of any special size can be made, its hight and diameter must be known, and three and one-seventh times the diameter gives the circumference or stretchout of the body pattern, and to this must be added edges for the seams and the wire. There must be some regard paid to the proportioning the various parts—the spout, the handles, sprinkler, etc. The sprinklers run from 4 inches in diameter down to 2 inches.

It is important to know how to notch the pieces properly, the top of the pattern for the take up of the wire, and the bottom notched so as to have only a single lap of metal when grooved and seamed together. Every experienced tinsmith understands the importance of this matter of properly notching patterns for seams and wiring. If a 3-16-inch wire is to be used, as shown in Fig. 34, then the pattern should be notched as shown in Fig. 35. The grooved seam should extend up to the center of wire, as shown at *m* in Fig. 34 and in the pattern at *p* in Fig. 35. The distance *p q* in Fig. 35 must be of sufficient width to cover wire, as shown in Fig. 34. In making allowance for the seam at each end of the pattern add one and one-half times width of edge or lock turned for the seam. If ⅛-inch edge is turned for the seam, then add 3-16 inch to each end of pattern, as shown by *n o* in Fig. 35. In notching the bottom of the pattern, where the ⅛-inch edge is used, cut away 3-16 inch on an angle of about 45 degrees. After the pattern is properly notched then punch out the hole in the pattern for the spout. After the pattern is edged, wired, formed, grooved together, and the bottom double seamed on, a suitable shaped top should be made, as shown by D in Fig. 28, and by the plan in Fig. 30, which is shown in the form of a crescent. Fig. 31 is the developed pattern of the crescent shaped water guard, as shown by D′ in the plan, Fig. 30, and as shown by D in the elevation, Fig. 28. Draw a horizontal line through the center of the plan in Fig. 30, extending it to 1, as shown in Fig. 31. With *h s* as a radius, as shown in the upper part of Fig. 32, and with *s*′ as a center and with *s* 1 as a radius, equal to *h s* in Fig. 32, scribe an arc as shown in Fig. 31. Then space off on the outer circle of the plan of the crescent,

as shown in Fig. 30, the points 1, 2, 3, 4, 5, 6, then transfer the same space to the arc thus scribed in Fig. 31. This gives the distance 1, 2, 3, 4, 5, 6 on enlarged circle in Fig. 31, the same as from 1 to 6 in Fig. 30. Make 1 *f* in Fig. 31 equal to *h k* in Fig. 32, the width of the crescent in the center. Draw line



Details, Proportion and Patterns of Watering Pots

from 6 to *f* at the center *h′* on this line 6 *f*, and at right angles with it draw line to *g*, and with *g f* as a radius scribe the arc at *f*, intersecting the outer circle at 6 on both sides and completing the pattern.

In Fig. 32 a method is shown of proportioning the crescent top to the various sizes of watering pots, so that the general proportion will be the same. The lower part of Fig. 32 shows a plan of the various sizes of watering pots. The relative position of *c* in the outer circle in Fig. 32 is the same as 6 in Fig. 30, as shown by dotted line 6 *c*. From *c* in the outer circle draw line to center *e*, cutting the other circles at points 1, 2, 3, 4. Above this plan in Fig. 32 draw the line *h g* at right angles with the center *e i*, and of sufficient length to intersect with perpendicular lines from the outer diameter of the plan. From points *c* 1, 2, 3, 4 thus established in the plan draw perpendicular lines intersecting line *h k*, and from the center *e* draw the horizontal line cutting through the circles at points 1, 2, 3, 4, 5, and from these points draw perpendicular lines intersecting the line *h* J. These points thus established on this line *h g* give the relative proportion in length in elevation of the crescent top for the various sizes of watering pots. To proportion the hight of the various sizes of these tops they must all have the same pitch, as shown by dotted lines, as the outer solid line.

Fig. 33 shows a method of proportioning the top bail or handle of the watering pot. The idea is to have the half-circle of the handle come even with the top edge of the crescent top, and *h' g'* forms the base line equal in width to the largest diameter. The hight is represented by *k' l'*. The lines *h' k'* and *k' J'* are what may be termed the grading lines, to proportion the length of the straight sides of the bails or handles for the various sizes of the watering pots.

Fig. 39 shows a method of proportioning the width of the handles, which naturally should vary according to the size of handle required. If the bail or handle for a 12-quart watering pot is made 1½ inches wide, smaller sizes must be proportionally less in width. The smallest, as shown, would be about ¾ inch wide. Add edges for wiring. In Fig. 29 the size and dimensions are given of watering pots of the following sizes: 1 quart, 3 quarts, 6 quarts, 9 quarts and 12 quarts, giving their various hights and diameters. The circumference is secured by multiplying the diameter by 3 1-7, and is practically near enough for an article of this kind. The circumference of a 1-quart pot is 12½ inches, so that the net size of pattern required, outside of seam, would be 4 5-8×12½ inches. So in like manner with the other sizes. A 3-quart pattern, net size, would be 7⅙×17⅔ inches; a 6-quart, 9×22 inches; a 9-quart, 10 3-8×25⅛ inches, and a 12-quart pattern, without seam, would be 11¾×27½ inches.

In Fig. 36 the points 1, 2, 3, 4 show the developed pattern of the spout E. This is secured by extending the tapering sides of the spout E until they intersect at *w*. Extend the upper line of the spout E with dotted lines to *y* the same

in length as the lower line of the spout E. Scribe the half circle x, and space off this half circle into a given number of points. Space off these same number of points with their duplicates on curved line y z between the points 5 and 6. This gives the circumference at the largest end of the spout E. Draw lines from all these points to w. From w draw lines down through the spout E intersecting the points established in the half circle x. With w as a center and the radius at the various points where these lines thus drawn intersect with the line of the body of the watering pot A, scribe the various arcs, as shown by dotted lines, and intersect them with the corresponding lines in pattern drawn to the center w. By connecting these points it gives the miter pattern 1, 4.

Fig. 37 is the developed pattern of the tapering part of the sprinkler F. Fig. 38 is the developed pattern of the socket on the end of the sprinkler that slips down over the end of the spout E to hold the sprinkler in position.

PATTERNS FOR SPRINKLING CAN

In Fig. 40 is shown a perspective view of a sprinkling can, the construction and patterns for which are shown in Figs. 41 to 43, inclusive. In Fig. 41 A shows the spout joining the body G at a and b. At c a zinc sprinkler head is soldered. The bottom B is seamed to the body as shown at e and d. The body of the can has an ogee swedge at m and m and a wire edge at f and i. The can lip has a wire edge at h and an edge to solder at f. The cross brace at J supports the spout, and is soldered at t and u. The handle is soldered at o and n, and r is the grasp. The handle shown by B in Fig. 40 is omitted in Fig. 41.

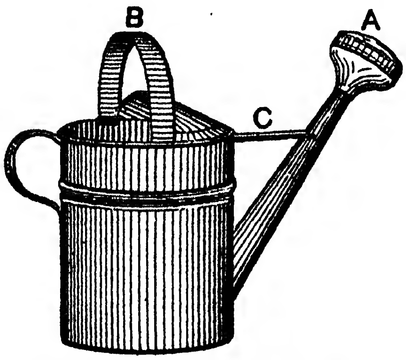


Fig. 40. General View of Can

The difficult patterns to be developed in this sprinkler are the spout, the opening in can to receive the spout and the lip. To avoid a confusion of lines these three patterns have been developed separately. The patterns for the spout and the opening in the can are shown in Fig. 42, though somewhat out of proportion to show clearly the principles involved. It should be understood that it makes no difference what the size of the can or spout may be, or at what angle it is placed, the rule holds good. Let A represent a part elevation of the can and B its plan.

Draw the outline of the spout as desired, as shown by C D E F and extend C D and F E until they meet in the apex at G. At will, extend the sides C D and

F E downward, making the distance G 5 and G 1 equal, and draw the diameter 1 5, upon which place the semiplan 1 3 5. Divide this into equal spaces as shown, from which points, perpendicular to 1 5, draw lines intersecting the diameter 1 5 at $2'$, $3'$ and $4'$, and from these points draw radial lines to G.

Through the center *a* of the plan B draw the line *a* G^1, which intersect by a vertical line dropped from G in elevation. Then G^1, which gives the apex of the spout in plan. From the various intersections, 1, $2'$, $3'$, $4'$ and 5, on the base of the cone in elevation, drop vertical lines cutting the center line in plan, as shown by similar numbers. Now take the various projections from the line 1 5 in elevation to points 2 3 and 4 in the semiplan, and place them on similar lines drawn into the plan, measuring from the center line *a* G^1, and obtain points 2 3 and 4.

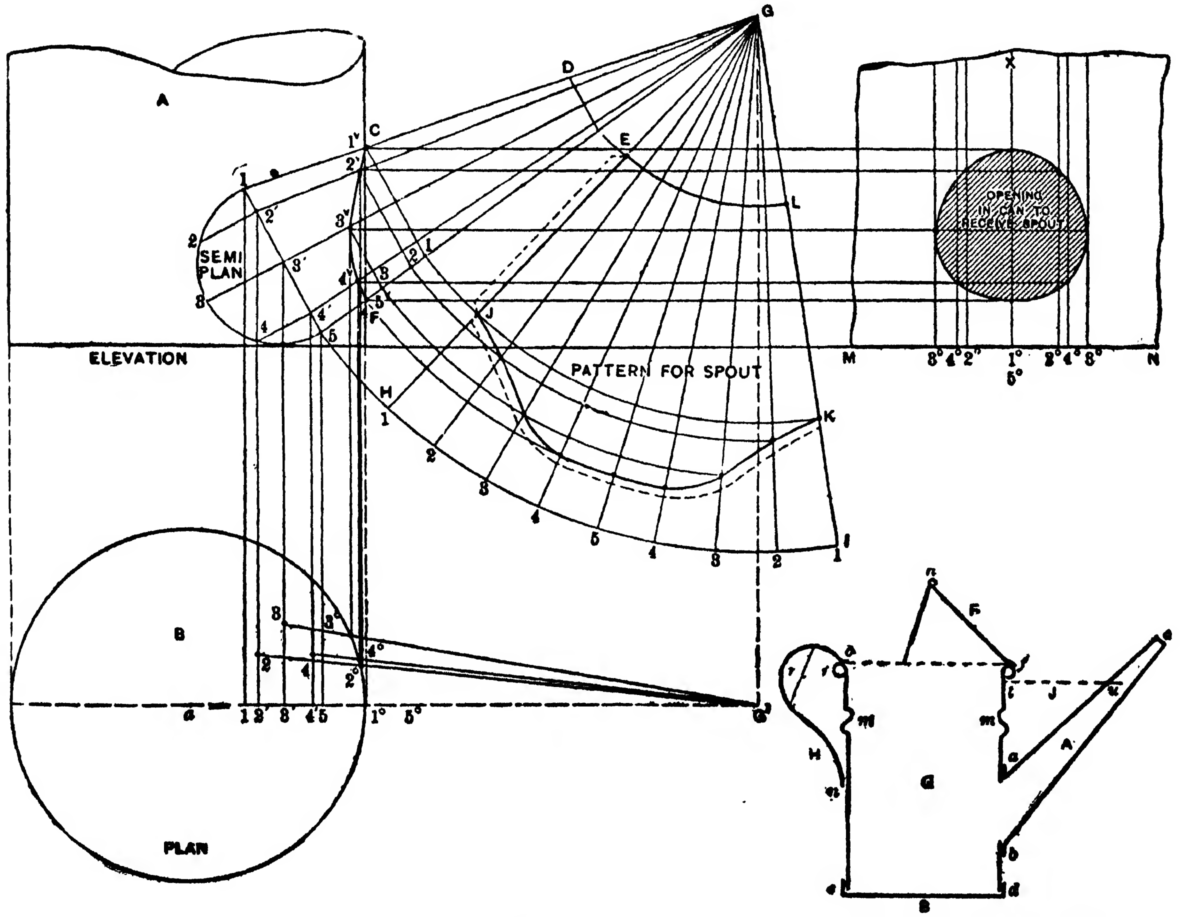


Fig. 42. Pattern for Spout

Fig. 41. Section of Can

From these points draw lines to the apex G^1, cutting the circle or plan of the can at 1°, 5°, 2°, 4°, 3°. From these points lines are erected into the elevation, cutting similar radial lines as indicated at 1^v 2^v, 3^v, 4^v and 5^v. A line traced through these points gives the miter line between the spout and can.

From the various intersections 1^v to 5^v, at right angles to the center line G 3, draw lines cutting the side of the cone E F from 1 to 5^v. With G as center and G 5 as radius draw the arc H I, upon which place twice the girth of the semiplan from 1 to 5 to 1, and draw radial lines to the apex G. Then with radii equal to G E, G 1, 2, 3, 4, 5^v draw arcs intersecting similar radial lines as shown. Trace a line through points thus obtained, and J K L E will be the pattern for the spout. Dotted lines show laps.

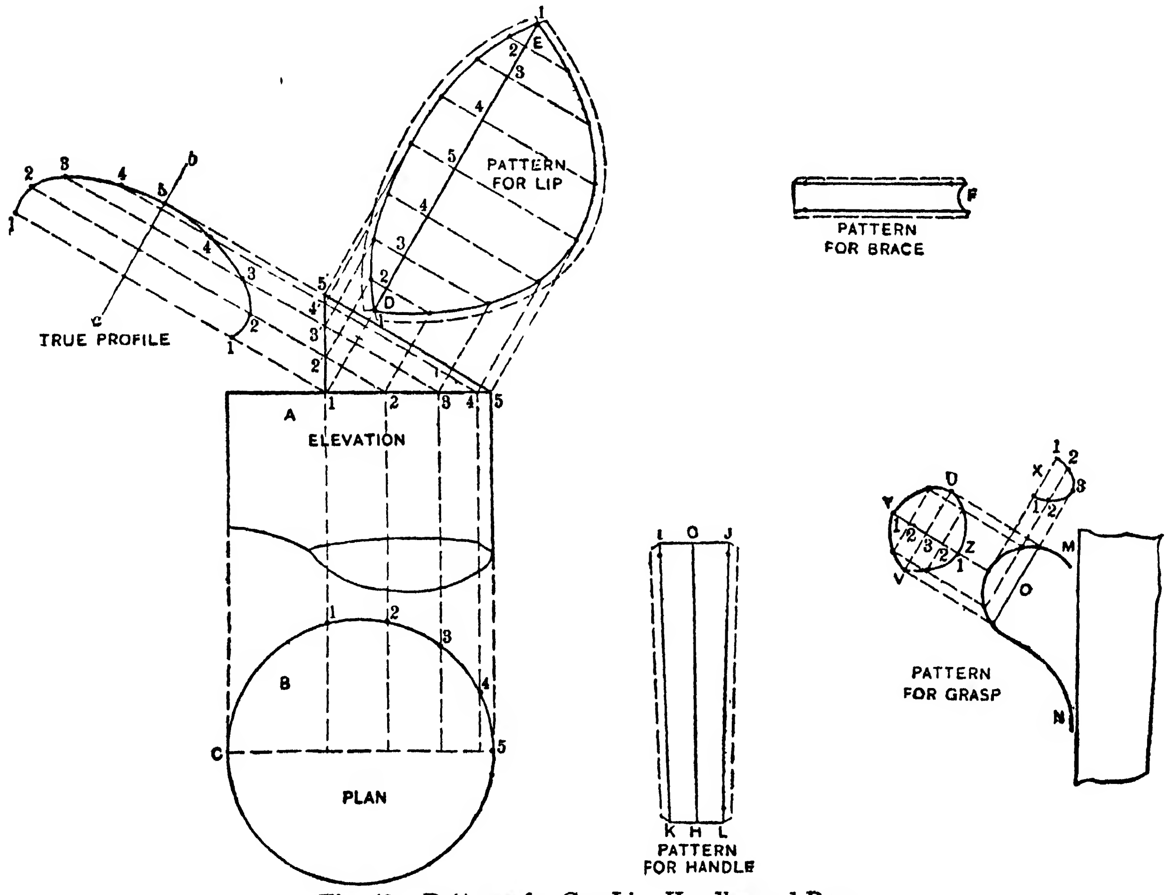


Fig. 43. Patterns for Can Lip, Handles and Brace

The opening to be cut into the can to receive the spout is obtained by taking the stretchout of 1°, 5°, 2°, 4°, 3° in plan, and placing this on the line M N on either side of the center line X. Vertical lines are now erected and intersected by horizontal lines drawn from similar numbers in the miter line C F in elevation. The shaded portion shows the shape of opening.

Four patterns are shown in Fig. 43, the one for the can lip being obtained as follows: Let A represent the elevation of the can and B the plan. Draw the center line C 5. Draw the angle of the lip desired, as shown by 5 5′ 1 in elevation, and extend 5′ 1, cutting the plan at 1. Divide the distance in plan from 1 to 5 as

shown, from which erect vertical lines cutting the can from 1 to 5 in elevation. From these points, parallel to the angle 5 5′, draw lines indefinitely, cutting the vertical line 5′ 1 at 4′ 3′ 2′. Draw the perpendicular line *a b*, then measuring from the line C 5 in plan, take the various projections to points 1, 2, 3 and 4, and place them on similar numbered lines in the true profile on either side of the line *a b*, resulting when a line is traced through points thus obtained in the true profile 1 5 1.

Take the girth of this true profile and place it on D E drawn at right angles to 5 5′, through which draw the usual measuring lines parallel to 5 5′ and intersect them by lines drawn perpendicular to 5′ 5 from similar numbered points on 5′ 1 and 1 5. The pattern for the lip is shown by the solid line, while the dotted lines show edges.

The pattern for the brace shown by C in Fig. 40 is shown by F in Fig. 43. Hem edges are allowed, the arc F being made to fit circle of spout. The side handle is shown at M N. The girth is taken and placed on G H; I J and K L are added with hem edges as shown; O in M N shows the side of the grasp, with its section shown at X. Divide X into equal parts as shown, and draw lines through these points parallel to O, cutting the outline of the handle as shown. The girth of X is now placed on Y Z, the usual measuring lines drawn and intersected by lines drawn at right angles to O from similar intersections on M N. The desired pattern is shown by Y U Z V. This same rule is applied if a grasp was desired on the top handle shown by B in Fig. 40.

INK FOR MARKING TINWARE, ATTACHING LABELS

A good ink for marking tinware is made by reducing asphalt or black varnish with turpentine to the desired consistency. It should be kept in a corked bottle, and, when wanted for use, the bottle should be shaken thoroughly. On withdrawing the cork enough of the marking fluid will adhere to it so that when the pen is applied to the cork it will fill with the fluid. This ink can be used for marking any bright article, as well as tinware, and it can be removed by means of a cloth dipped in coal oil or turpentine. Another ink is made by reducing shellac varnish with alcohol and adding a sufficient quantity of the finest lamp black. This forms a jet black lusterless ink, which is insoluble in water, but can be removed by a drop of alcohol.

There are occasions when it is desirable to attach labels to tin, and as ordinary paste or mucilage is not adapted to the purpose, the following methods are given:

1. If the paper is well sized and will resume its original color when the paste is dry, use a solution of balsam of fir, 1 part, in oil of turpentine, 2 or 3 parts.

2. Soften 1 part of good glue in water, then pour off the excess, and boil it with 8 parts of strong vinegar (about 8 per cent.). Thicken the liquid, while boiling, with enough of fine wheat flour or dextrin.

3. Make starch paste and add to it while warm a little Venice turpentine, so that the latter will become evenly distributed through it.

4. Add to starch paste, or any other similar aqueous paste (except that made from gum Arabic), some solution of shellac in borax. The quantity may be easily determined by trial.

5. Paint the spot where the label is to be put with a solution of tannin and let it dry. Affix the label, previously gummed and wetted.

6. Paint the spot over lightly with a camel's hair brush dipped into chloride of antimony.

7. Make a dilute solution of white gelatin, or, better, of isinglass, about 1 in 20. This is said to adhere without the addition of anything else.

8. To mucilage of acacia, starch, dextrin or tragacanth paste, add a little ammonia.

9. Or add a little tartaric acid. A trifle of glycerin may be added besides.

10. Mucilage of gum Arabic may be made much more adhesive by heating 100 parts of it with 2 parts of sulphate of aluminum, previously dissolved in hot water, to boiling, and then allowing to settle. A little tartaric acid and some glycerin added to the clear liquid after it is decanted will improve it.

11. Make a mixture of mucilage of tragacanth, 10 parts, and flour, 1 part.

PATTERN FOR COPPER STOVE RESERVOIR

For the most correct and quickest way to make a copper stove reservoir out of 14×48-inch sheet copper, with two seams in the body, the finished reservoir to be 12 inches deep, 17×10 inches at the top and 16×9 inches at the bottom, proceed as follows:

Assuming the body is to be in two pieces, with seams at two corners, it will require using stock size of 14-inch wide copper, a length of 28 inches for each half pattern, and the correct rule for laying out the pattern direct upon a sheet of copper without using any drawings but the measurements above given, is in Fig. 44. Let A B C D represent a sheet 14×28 inches in size; draw the line E F parallel to A

B, making the distance A E equal to the width of the top flange, and place E from the edge A D as much as required for edges for seaming. Make E F equal to 17 inches and bisect the line as at G. From G, at right angles to E F draw G H, equal to 12 inches, and from H, parallel to E F, draw I J, making H I and H J each equal to 8 inches, making I J 16 inches; draw lines from E to I and F to J. Then will E F J I be the pattern for the long side. As the flare is equal all around, with F as center and any radius, describe the arc K L, intersecting the line F J at M. With M as center and M K as radius intersect the arc K L at

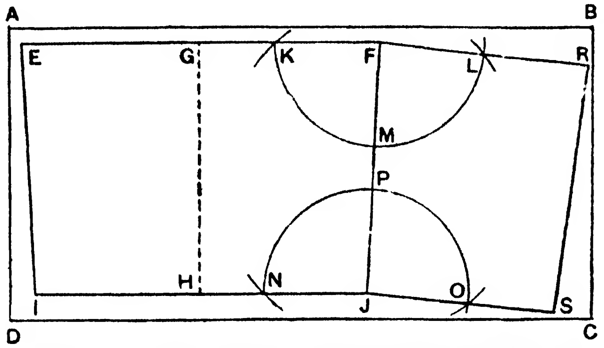


Fig. 44. Body Pattern of Copper Stove Reservoir

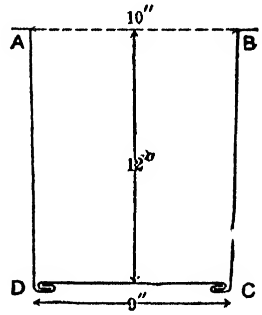


Fig. 45. End Section

L. Draw a line from F through the intersection L, as F R, which make equal to 10 inches. In similar manner the angle P O can be made equal to P N; or, from J draw the line J S parallel to F R, making J S equal to 9 inches, and draw line from R to S. Then will E F R S J I represent a one-half pattern for the reservoir, flanges to be allowed for seaming. It will be noticed that the distance from G to H was made 12 inches, or the depth of the article, because in this case the flare, as shown from B to C in Fig. 45, is but 1-32 inch more in length than the straight hight. If, however, the flare was greater, the distance from B to C would be the length from G to H in Fig. 44. In Fig. 45 is shown the section through the article with flanges at A and B and double seams at the bottom at C and D. If desired, the corners can be slightly rounded. It is suggested that 28-inch wide copper be employed; as that is stock size, no waste will result.

PATTERN FOR ICE CREAM MOLD

An article which can be made from IX tin or No. 24 galvanized iron, is an ice cream mold (brick form). In Fig. 46 is shown a perspective view of the mold with cover. The corners can either be riveted, as shown by C and D, or double seamed. The seams should be soldered on the inside in such a manner that the

inside surface will be as perfectly smooth as if the mold were stamped in one piece. While some molds are made perfectly square—that is, no bevel is given to the sides—this pattern is cut on a bevel to allow the cream to slip out easily.

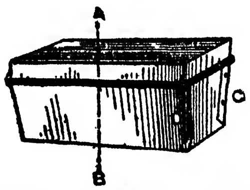


Fig. 46. Perspective View of Finished Ice Cream Mold

In laying out the pattern it is not necessary to draw the entire form, but only one corner. Providing that all the sides have the same bevel, this one corner pattern is all that will be required to obtain the pattern in one piece. In Fig. 47 let 1, 2, 3, 4 be a section taken through A B in Fig. 46; 1, 2, 3 in Fig. 47 being the body of the mold, with wire at 3, while 4 indicates the cover. For the pattern for the corner draw any line, as C D, at right angles to a 1, upon which place the stretchout of 1, 2 and 3 in the section, as shown by 1, 2 and 3 on C

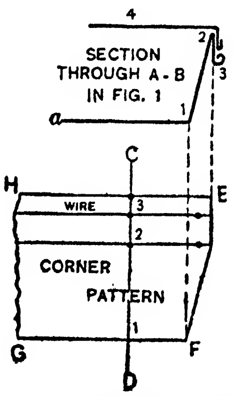


Fig. 47. Method of Obtaining Pattern for One Corner

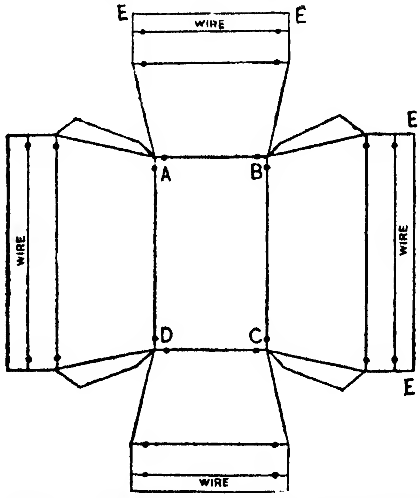


Fig. 48. Pattern for Mold in One Piece

D, also allowing for wire, as shown. At right angles to C D and through the small figures draw lines, as shown, which intersect with lines drawn at right angles to a 1 from intersections 1, 2 and 3 in the section. Trace a line through points thus obtained. Then will E F G H be the corner pattern.

Assuming that the bottom of the mold is to be of a given size, as shown by A B C D in Fig. 48, around which the sides are to be constructed, take the pattern G F E in Fig. 47, and, laying the line G F successively against the corners and lines A B, B C, C D and D A in Fig. 48, turning the pattern right and left as required, mark off the miters E, E, E, etc., as shown. Then will the pattern shown in Fig. 48 be the full pattern for the mold in one piece. Allowance must be made for seaming or riveting, as shown. The pattern for the cover 4 in Fig. 47 is so simple that a description is omitted.

PATTERN FOR TUMBLER DRAINER

The finished view of a tumbler drainer is shown in Fig. 49. This article can be made from zinc, galvanized iron, bright tin, copper and brass. When made from polished sheet brass or copper it has an attractive appearance on a counter. Those made of the first three materials are usually japanned in colors. It will be noticed a heavy beaded edge is placed at *a a*, while at *b b b* buttons are soldered to prevent the bottom of the pan from scratching the counter. If desired, ornamental brass legs can be used on the copper and brass drainers.

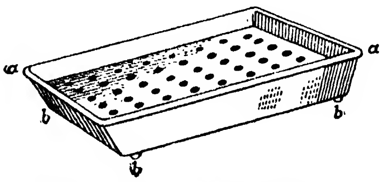


Fig. 49. Perspective View of Tumbler Drainer

Fig. 50 shows the cross section through the pan, with a wired edge at *a a*, and *b*, *b′* and *b* represent small angles bent to the shape shown and soldered to the ends and sides. On the top of these the drainer *c* rests. In the drainer *c* small perforations are made with a ⅜-inch hollow punch. After punching these holes on a block of lead the burr should not be flattened, but should remain as shown in *c*, which forms a drip. Around the drainer *c* bend down ¼ inch all around to stiffen the edges. The concave buttons *f* and *f* are punchings obtained from a 1-inch hollow punch. These punchings are concave, and in that shape should be soldered to the bottom of the pan.

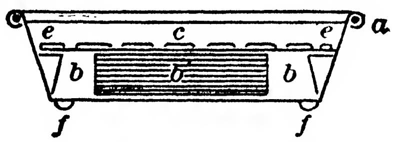


Fig. 50. Sectional View

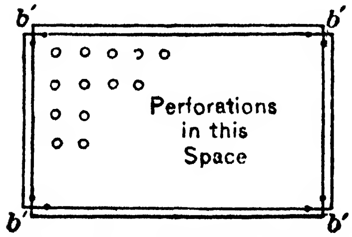


Fig. 52. Pattern for Drainer

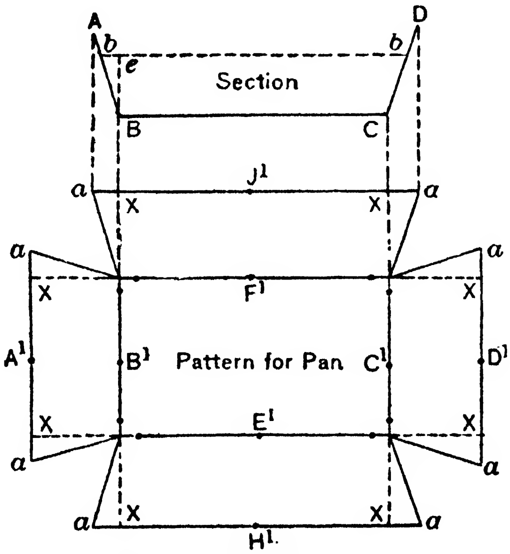


Fig. 51. Pattern for Pan

Fig. 51 shows how the patterns for the drainer and pan are developed. A B C D is a reproduction of *a f f a* in Fig. 50, minus the wire or beaded edge. Draw the desired bottom of the pan below the section, as shown by B^1 C^1 E^1 F^1. Take

the distance of A B or C D in the section and place it at right angles to the sides of the bottom, as shown by A^1, J^1, D^1, H^1. Through these points draw the lines *a a* on each side, parallel to the sides. At right angles to B C in section, and from the points A and D, drop lines intersecting the line J^1 and H^1 at *a a a a*. Take the distance from X to *a* and place this projection at the ends on the lines A^1 and D^1, as shown. Connect lines, as shown, which will be the desired pattern, to which allowance must be made for seaming and wiring.

The pattern for the drainer, represented by *b b* in section, is cut, as shown in Fig. 52, as much larger than the bottom of the pan as the projection *e b* in section indicates. In other words, if the bottom of the pan measures 10×14 inches, and the projection *e b* equals ½ inch, then will the pattern for drainer *b' b' b' b'* measure 11×15 inches, to which edges are allowed. Perforations are made in the space shown.

PATTERN FOR PAN WITH WATER TIGHT CORNERS

A perspective view of a pan in which the corners are made water tight is shown in Fig. 53. This is accomplished by means of folding the corners together and turning them to the sides, or ends, as shown by *a* and *b*. Perhaps it would be more readily understood to say that this procedure is commonly called, "Making drip pans."

The usual practice in the shop is to lay off the pattern directly on the metal, using the steel square and dividers. These pans can be made from tin, black or plainshed iron, galvanized iron, copper or brass. When made from tin or black iron they are used for baking; from planished iron for roasting, from galvanized iron for drip or water pans, and from polished copper or brass for confectioners' displays.

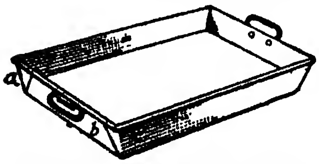


Fig. 53. Perspective View

In Fig. 54 is shown the method employed in obtaining the pattern for a pan the flare of which is equal on all sides. Draw A B C D, the elevation of the pan. Directly below it draw E F G H, the bottom. Take the distance C to B and place it at right angles to the ends and sides of the bottom, as shown by B^1 B^2 B^3 and B^4, through which draw lines parallel to the ends and sides, as shown. Extend E F, H G, F G and E H, intersecting the lines just drawn at *b b'*, *c c'*, *d d'* and *e e'*. Take the projection of the flare *a* B in elevation and set it off on the four sides of the pan, as shown by *b a'*, *c a'*, *d a'*, *e a'*, *c' a'*, *b' a'*, *e' a'* and *d' a'*. From the points *a'* draw lines to the corners E, F, G and H, which

would complete the pattern for the pan if the corners were soldered together raw edge.

To find out the amount of material necessary for folding the corners proceed as follows: If the flare is equal on all sides bisect the angle E F G. To do this use F as center, and with any radius draw the arc *f h*, intersecting E F and F G at *f* and *h*. Then, using *f* and *h* as centers, and with radius greater than half *f h*, draw arcs intersecting each other at *i*. Draw a line through *i* and F, as shown by *i j*. Then, using *a′* as center, with radius less than would meet *i j*, describe the arc *b m*, intersecting *a′* F at *n o*. Then, with *n* as center and *n b* as radius, describe an arc intersecting the arc *b m* at *o*. Draw a line from *a′* through *o*, intersecting the line *i j* at *l*. Draw a line from *l* to *a′*. Then will *a′* F *a′ l a′* be the desired corner, which should be traced on each corner.

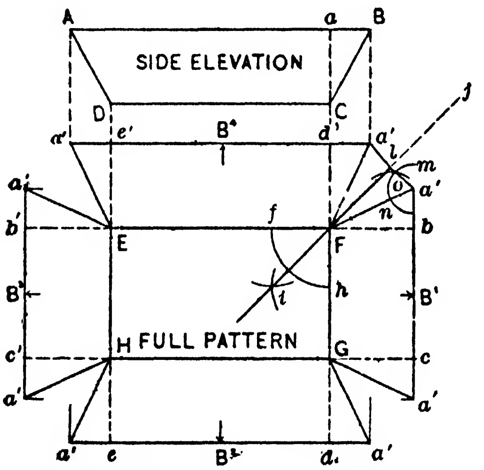


Fig. 54. Pattern for Pan with Equal Flares on All Sides

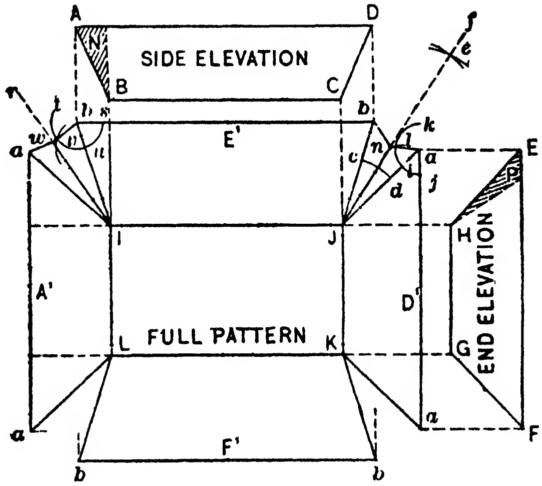


Fig. 55. Pattern for Pan with Different Flares on Sides from Ends

If a pan is desired, the ends of which have a different flare from those of the sides, as is shown in Fig. 55, in which A B C D shows the side elevation and E F G H the end elevation. In its proper position, draw the bottom of the pan I J K L. Take the distances C to D and B to A in side elevation, and G to F and H to E in end elevation, and place these distances at right angles to the ends and sides of the pan, as shown respectively by A^1, D^1, F^1 and E^1, through which points draw lines parallel to the ends and sides, as shown. Intersect these lines by lines drawn from A to D in side elevation, and E and F in end elevation, thus obtaining the intersections *b*, *b*, *b*, *b*, and *a*, *a*, *a*, *a*. Draw lines from the points *a* and *b* to the corners I, J, K and L, as shown, which would complete the pattern for the pan if the corners were soldered together raw edge.

In making these pans of unequal flare the folded corners are sometimes turned toward the ends of the pan, while they are sometimes folded toward the sides of the pan. Assuming that the corner is to be turned toward the end of the pan, as shown at P in end view, bisect the angle *b* J *a* in pattern, obtaining the line of bisection J *f*. With *a* of the *end miter* as center, and with radius less than would touch J *f*, describe the arc *j k*, intersecting *a* J at *i*. With *i* as center and *i j* as radius intersect *j k* at *l*. Draw a line from *a* through *l*, intersecting the line *f* J at *n*. From *n* draw a line to *b*. Then will *b* J *a l* be the pattern for the folded corner when it is turned toward the ends.

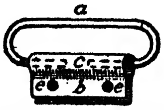


Fig. 56. Hinged Wire Handle

When the corner is to be turned toward the sides of the pan, as shown by N in side elevation, bisect the angle *b* I *a* by the line I *r*, and using *b* of the *side miter* as center, describe the arc *s t*. Then, using *u* as center and *u s* as radius, intersect the arcs *s*, *t*, at *v*. Draw a line from *b* through *v*, intersecting *r* I at *w*, and draw a line from *w* to *a*. Then will *a* I *b w* be the pattern for the folded corner when it is turned toward the sides. Note the difference between the shape of the two corners.

When making roasting, baking and drip pans the wire hinged handle is usually employed, as shown in Fig. 56, which shows the wire handle *a* fitting into the loop of the metal *b* at *c*. Holes are punched at *e* and *e* for riveting to the ends of the pan, as shown at *b* in Fig. 53.

In the confection pans made of brass or copper, stationary handles, as shown at H in Fig. 57, are used. The method of obtaining the pattern is shown in the same figure. Let A B C represent a portion of the pan, and E the side view of the handle. Draw the shape the handle is to have on the line 1′ 3′, as shown by D, which divide into equal spaces, as shown by the small figures 1 to 3 on either side, from which draw vertical lines intersecting the bottom of the handle E at 1′ 2′ and 3′, from which points, parallel to 1′ 1″, draw lines indefinitely, as shown by 1°, 2°, 3°, intersecting the side of the pan A B at 1″, 2″, 3′. A true section must now be obtained on the line E 3′, as follows: Draw 1^x D^1 at right angles to 1′ 1°. Measuring from 1 D, take the distances to points 2 and 3 and place them on similar numbered lines, measuring from the line 1^x D^1, thus obtaining the points 1^x, 2^x, 3^x on both sides, through which trace a curved line, which will be the true section on E 3′ in side. For the pattern extend the line 3′ E, as E E^1,

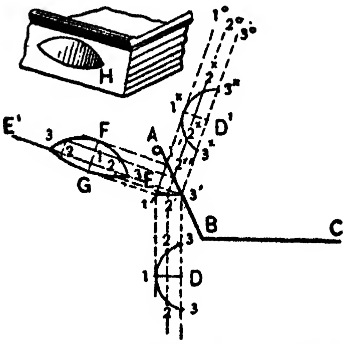


Fig. 57. Pattern for Soldered Handle

upon which place the stretchout of the profile D^1, as shown by similar figures on $E\ E^1$. At right angles to $E\ E^1$ and through the small figures draw lines, which intersect with lines drawn from similar numbered intersections on A B and $3'\ 1'$ at right angles to $1'\ 1''$. Trace a curved line through the points thus obtained. Then will 3 F 3 G be the pattern for the handle. These handles are generally soldered to the pan on the inside of the handle H. Any solder showing is scraped off.

CAKE CUTTERS

Bright pieces of scrap tin can be utilized to make lady finger, patty, biscuit, doughnut, cookey, cake, animal, tart and muffin cutters. These are easily made, prove attractive, and sell readily if an assortment of forms is kept on hand. In Fig. 58 is shown a variety of simple forms. To make the full sized drawings of these figures the method shown in Fig. 59 may be used. Divide the length of the smaller outline into an equal number of spaces, as shown by the small figures 1 to 8, and the hight into any number of equal parts, as shown from a to g. Through the small figures 1 to 8 and letter a to g draw lines at right angles to each other, intersecting each other, as shown, and crossing the outline of the figure.

Assuming that the outline of the horse is to be made twice the size of the small diagram, set off a distance equal to twice the amount of 1 to 8, as shown by $1'$ to 8, and twice the hight $a\ g$, as shown by $a'\ g'$. As 1 to 8 is divided into eight parts, and $a\ g$ into seven, then divide $1'$ to $8'$ into eight parts and $a'\ g'$ into seven, respectively. Through points $1'$ to $8'$ and a' to g' draw lines

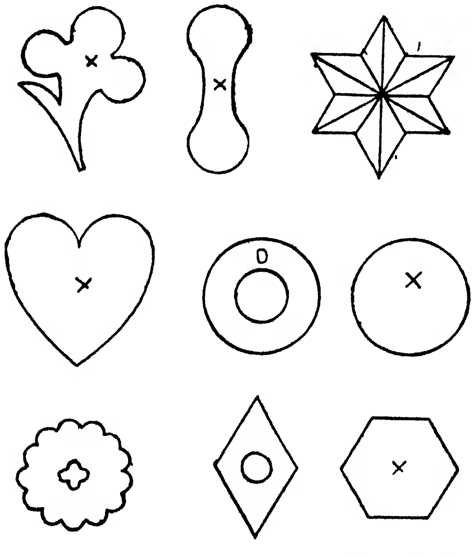


Fig. 58. Simple Forms of Cake Cutters

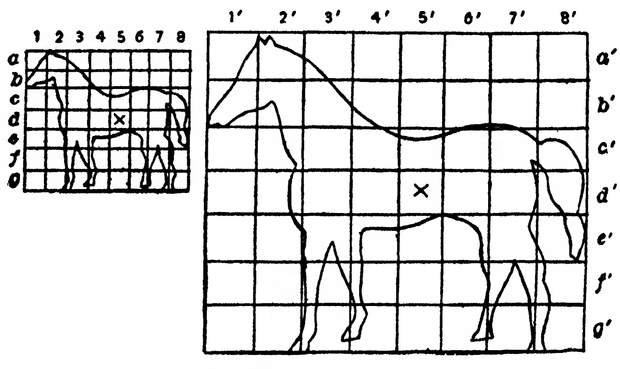


Fig. 59. Method of Enlarging Figures

at right angles to each other, as shown. Following the smaller diagram as a guide, the large one is traced through corresponding squares. In this manner any figure

can be enlarged to any size. If the outline was required six times as large as the small diagram, then would the length 1 to 8 and hight *a g* be made six times as large; divide the spaces thus obtained into the same number of divisions as in the original diagram. In Fig. 60 is shown an outline of a bird and barking dog. These or any other figures can be enlarged, using the above method. A mechanical instrument known as a pantograph can be bought from a dealer in drawing instruments. The cost of these is not large and usually full instructions are furnished.

The cutters are constructed as shown in Fig. 61, in which A represents a flat piece of tin of the required size, onto which strips of tin ⅜ inch wide, which have been formed to the outline of the figure desired, are tacked with solder at *a* and *a*.

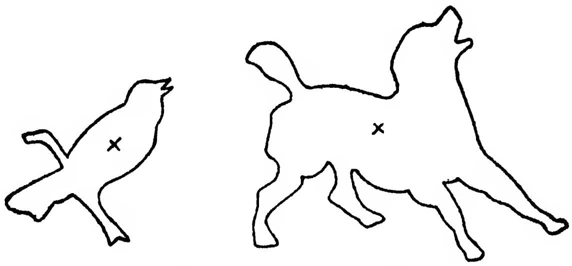


Fig. 60. Bird and Dog

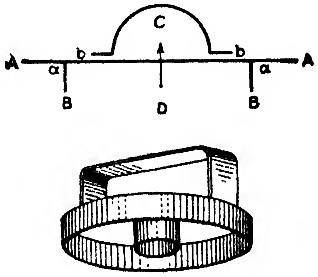


Fig. 61. Construction of the Cutter

Then a handle, shown at C, about ½ inch wide, with a hem edge bent toward the inside, is soldered to the flat disk A at *b* and *b*. A ½-inch hole should be punched through the center of the disk, shown by the arrow point, also as is shown in all the diagrams by X in Figs. 58, 59 and 60, which allows the surplus dough to pass out at the top when cutting the various figures. D in Fig. 61 shows a perspective view of a doughnut cutter, showing how the handle and strips are put together, being the finished article of D in Fig. 58.

DETAILS OF A PEANUT HEATER

One of the simplest forms of a peanut heater, fulfilling the requirements of ordinary conditions, is shown in the accompanying illustrations, Fig. 62, showing a side and Fig. 63, an end view. First make the rectangular box A B D C, Fig. 62; from A to B, 18 inches; from C to D, 16 inches, and the straight depths

inches. From A to B, Fig. 63, is 10 inches, and C to D, 8 inches. Double seam the corners and bottom and solder well. Rivet in position 3 inches from the bottom a partition to form a water chamber, as shown, leaving holes for the tube

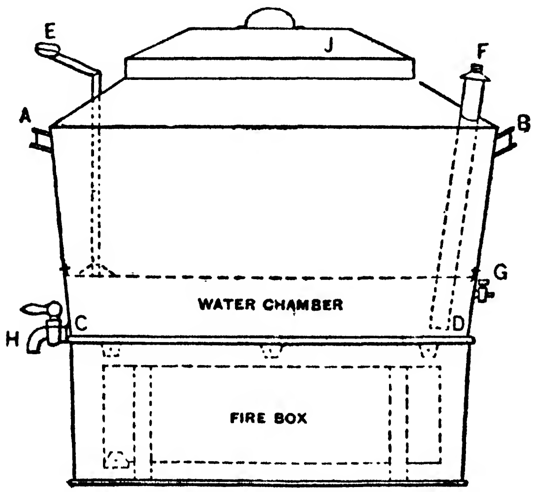


Fig. 62. Side View of Peanut Heater

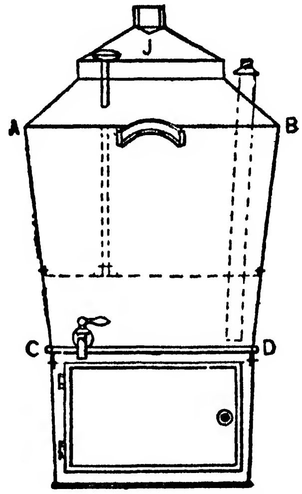


Fig. 63. End View

E for steam whistle, 3-8 inch in diameter, and F for a water filler, 1 inch in diameter, having a screw cap at the top with a small hole in it, which will indicate when water is low by emitting steam. Put in a small pet cock at G, which will be high water mark, and a faucet at H to empty reservoir. Make the breast with a rim 1 inch high, into which will fit the cover J, which should fit easily and may be hinged if desired. Now make the rectangular box to hold the fire pan, wire it around the top, and swing a door at each end. Rivet three braces of 1-inch band iron across, as shown, upon which will rest the upper section. Punch ½-inch holes along the top of each side, to let out the gas from the burning charcoal. The fire pan, which is shown in Fig. 64, is made semi-cylindrical in form, 5 inches wide and 14 inches in length, perforated with 3-8-inch holes, to permit the combustion of the charcoal, which may be regulated by a draft slide placed in one of the doors. This pan must be supported by legs made from 1-inch band iron, so that the air has free circulation all around it; also rivet a small lug at each end, to admit a handle made after the manner of a stove lifter, by which the fire pan may be removed without burning the hands. The whistle is made from two disks 1½ inches in diameter, raised and soldered together, and having a small hole in the under side, upon the edge of which the steam is blown.

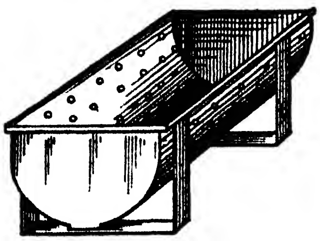


Fig. 64. Fire Pan

CANDLE MOLDS

That the tinsmith, or sheet metal worker as he is now called, may receive an order for an article that is practically obsolete is evidenced by the receipt of a description from a tinsmith of candle molds, made by him pursuant to an order. Hence, the presenting here of this description may be of use to others.

Fortunately this tinsmith had the opportunity to borrow an old mold made in the days of candles and was thereby saved the need of experimenting. The new candle mold is shown with the wicks in place and the drawing bar ready to pull the candles out of the mold after the tallow has hardened. Resting across the new one is the old candle mold that is now covered with rust and not fit for service, though it furnished the dimensions from which the new mold was made, as portrayed in the illustration, Fig. 65. The top, which serves as a funnel, accommodates molds for three candles and is 1⅝ in. wide, 3½ in. long and 1 in. deep. The molds are tapering, ⅞ in. in diameter at the top and ¾ in. in diameter at the bottom and 9¾ in. long. They are finished at the bottom with a short cone open at the apex, so that the wicks can be passed through and knotted.

The cylinders for the molds were formed on the candle mold stake that is in every tinshop but seldom used for its original purpose. The cones were formed on the beakhorn stake and all the parts were soldered together. Where a large number of candles were made in former times, 6 and 12 molds were assembled instead

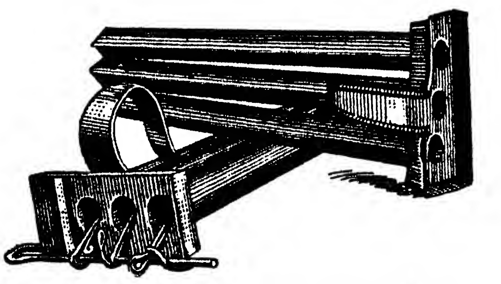


Fig. 65. The Old and New Candle Molds

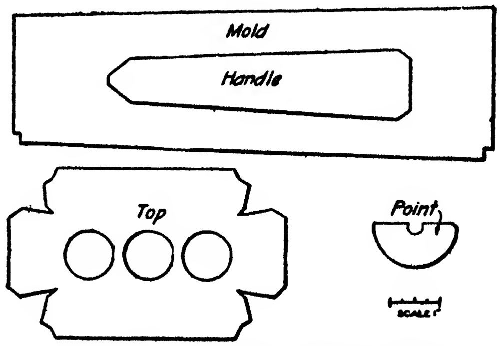


Fig. 66. Patterns for Candle Molds

of 3 as in the picture, and then instead of being soldered together at the bottom they were passed through holes in a tin brace similar to that at the top. This held them farther apart and quickened the cooling. Usually the mold is immersed in water when the candles are poured, so that if the tallow is hot it cannot possibly melt the solder. A suitable handle is an essential part and is soldered to the mold, as seen in the picture. The patterns for all the different parts are shown about one-quarter of the full size in Fig. 66.

PATTERN FOR SCALE SCOOP WITH FUNNEL END

A scale scoop with a funnel on one end is shown by Fig. 67, which gives the side view, section and radii of such a scoop. To make the pattern for this a correct side view of the scoop should be made, as follows: Draw any horizontal line, as L M. At right angles to L M draw the line B D, and make the distance 4 to D the same as 4 to B, then locate the points A and C, and draw lines A to B, B to C, C to D and D to A. Place the tube G H I J, as shown, and at pleasure draw the curve F K E. Then will J D E K F G be the side view of the scoop. With a radius equal to 4 B or 4 D and N on the line L M as center, describe the circle R P O M, which will represent a section through the line B D in side view. Divide the half circle O P R into equal spaces, as shown by the small figures 1 to 7, and from which, parallel to L M, draw lines intersecting the line B D from 1 to 7, as shown. From points 1 to 5 on D B draw lines to the apex C, while from points 5 to 7 draw lines to the apex A. Where the radial lines 2, 3 and 4 intersect the curve K E, draw at right angles to L M, lines intersecting the bottom of the scoop D C at 1′, 2′, 3′ and 4′. In similar manner, where the radial lines 5, 6 and 7 intersect the curve K F draw lines at right angles to L M, intersecting the scoop line J D at points D, 6′ and 7′.

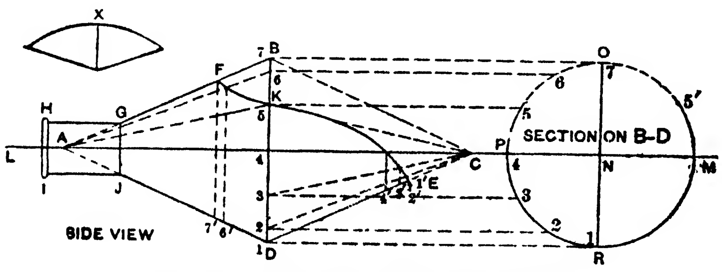


Fig. 67. Side View, Section and Radii

For the pattern for the one-half of the scoop K E D, the part without the funnel, take C D as radius and C in Fig. 68 as center and describe the arc 5 5. Draw the radial line C 1. The scoop on the line K D in Fig. 67 has only a part of the circle for its profile, as shown from 5 to 5′ in section, Fig. 67. Take the stretch-out from 1 to 5 in the section, and place it on either side of the point 1 in Fig. 68, as shown from 1 to 5. From these small figures draw radial lines to the center C, as shown. With radii equal to C 4′, C 3′, C 2′ and C 1′ in Fig. 67, and with C in Fig. 68 as center, intersect radial lines having similar numbers, as shown by 4′ 4′, 3′ 3′, 2′ 2′ and 1′, respectively, as shown. Trace a curved line through intersections thus obtained, as shown, from 5 to 1′ to 5, which completes the pattern. If a scale scoop were desired of a shape similar to X in Fig. 67, a duplicate of the pattern shown in Fig. 68 would be required and joined on the line K D in Fig. 67. The usual method of joining is to turn edges on each part as one would do in seaming elbows; but instead of leaving the seaming standing, it is doubled over.

For the opposite half of the scoop G F K D J, take A D as radius and with A in Fig. 69 as center describe the arc 7 7. Draw any radial line, as A 1, and set off on either side of point 1 the stretchout of the semicircle R P O in Fig. 67, as shown by the small figures 7 to 1 to 7 in Fig. 69. From points 5, 6 and 7 draw radial lines to the center A. Now with radii equal to A 7′ and A 6′ in Fig. 67 and A in Fig. 69 as center, intersect radial lines having similar numbers, as shown by 7′ 7′ and 6′ 6′. Trace a line through points thus obtained, as shown from 7′ to 5 and 5 to 7′. With radius equal to A J in Fig. 67 and with A in Fig. 69 as center, describe the arc J J. Then will J 7′ 5 1 5 7′ J be the desired pattern. Allow edges to all patterns for wiring and seaming. The tube shown by H G J I in Fig. 67 should have a wired edge at H I, as shown.

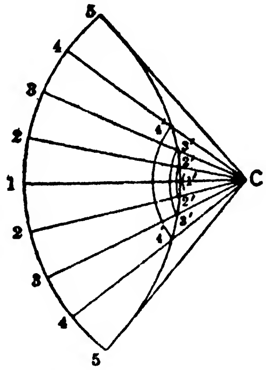


Fig. 68. Pattern for Half Scoop K E D in Fig. 67

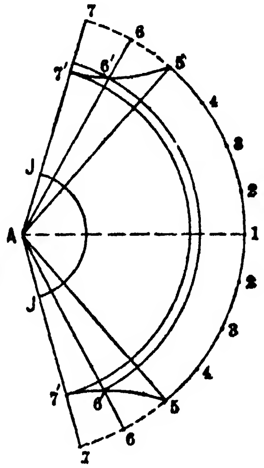


Fig. 69. Pattern for Half Scoop D K F G J in Fig. 67

PATTERNS FOR COLANDER

A perspective view of a colander, which is usually made from bright IC or IX charcoal tin, is shown in Fig. 70. The handles shown at A and A are tinned malleable iron handles, and are riveted to the body of the colander. They can, if desired, be made from tin plate and soldered on. A wired edge is placed at the top and at the bottom, as shown at *a* and *b*, respectively.

The patterns for the colander are obtained as shown in Fig. 71, in which first draw the center line A B, upon which place the hight of the colander, as shown by A K. Draw the desired dimensions on either side of the center line, as shown by C D, E F, and G H. Extend the lines D E and C F, intersecting the center line A B at I. With K as center draw the semicircle 0 3 6, which divide into equal spaces, as shown by the small figures 0, 1, 2, 3, 4, 5, 6. Using I as center, with radii equal to I E and I D, draw the arcs N O and L M, respectively.

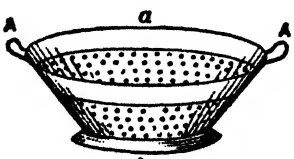


Fig. 70. Perspective View of Colander

From any point, as L, draw the radial line L I, intersecting the arc N O at N. On the arc N O, starting from the point N, set off the stretchout of the semicircle 6 3 0, as shown by similar figures on N O. From the center I draw a line through O intersecting the arc L M at M. Then will L M O N be the half pattern for the body of the colander, to which laps must be allowed for seaming and wiring.

For the pattern for the base or foot of the colander extend the lines H E or G F in elevation until they intersect the center line at J. With radii equal to J F and J G and with B on the center line A B as center, describe the arcs E^1 F^1 and H^1 G^1, respectively. From G^1 draw the radial line to B intersecting the inner arc at F^1. From the point F^1 lay off on the arc F^1 E^1 the stretchout of the semicircle 6 3 0, as shown by similar figures on F^1 E^1. From the center B draw a line through E^1, exending it until it intersects the arc H^1 G^1 at H^1. Then will H^1 G^1 F^1 E^1 be the pattern for the foot of the colander. Laps must be allowed for edging and wiring. P in the front elevation indicates a small swedge, or bead, turned into the colander, below which perforations are made, which are also shown in the pattern. The bottom of the colander, which should also be perforated, is shown by the circle K. This bottom is oftentimes raised, so as to present a surface sufficiently stiff for all purposes, and the removal of buckles.

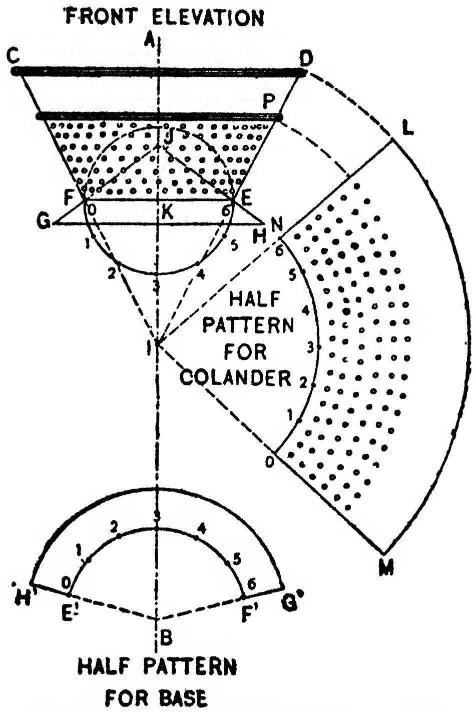


Fig. 71. Front Elevation and Patterns

TIN BASINS

The sizes and dimensions of basins presented on page 343 have long been the standard. This schedule in former years had a special value, because of the fact that such articles of tinware, as well as nearly all others, were made in larger quantities, such as gross lots, and the sizes of patterns were so proportioned as to cut stock to the best advantage with the least possible waste. In the illustrations herewith, it

has been aimed to show how this is accomplished with the least possible expense under the old regime of hand made tinware, as well as giving the required size of the various patterns.

Fig. 72 represents 1-pint, 3-pint and 2-quart tin basins, respectively. The pattern for the pint basin is made in two pieces, as shown by A in Fig. 72. In this pattern all edges must be allowed—3-16 inch on each end for lock seams, ⅛-inch edge on bottom, and ¼ inch at top for wire. Having allowed these edges, all the full size patterns required are in possession. It is found that you can get four pieces out of a 10×14-inch sheet, as shown in Fig. 73. These basins are

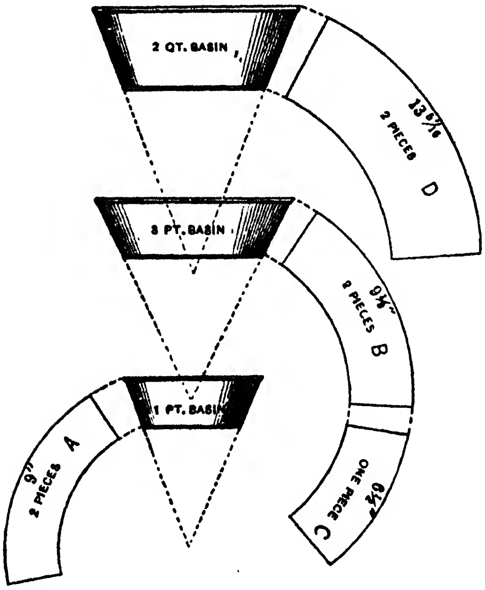


Fig. 72. 1-Pint, 3-Pint and 2-Quart Basins

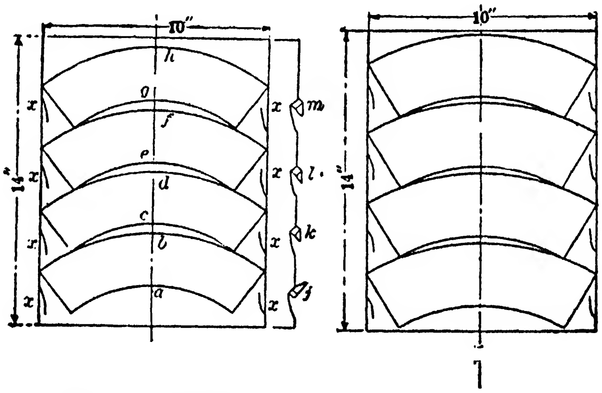


Fig. 73. Marking the Patterns on the Tin

made out of either IC or IXX tin, according to the quality of goods desired. When made of IC, the lightest tin, three sheets are cut out at a time, being locked together, as shown by *j*, *k*, *l* and *m*, in Fig. 73. The three sheets are first notched, as shown by *x*, *x*, *x*, *x*, on both sides of the sheet in Fig. 73. After thus notching the sheets first turn the lug up, then down on the back as at K. This completes the process, with the exception of flattening down the locks with a mallet, being sure that the point does not stand up, which naturally would tear the hands of the operator. This method holds the sheets firmly together.

When three sheets are cut out together only the top sheet is to be marked. When IXX tin is used for these basins it would be impracticable, if not impossible, to cut more than two sheets at a time. But the process of holding the sheets together by means of locked edges is the same as when IC tin is used. In either case, whether IC or IXX tin is used, the stock or bench shears should be used for cutting out. These are held firmly in position on the bench by means of a

hole or socket cut into the bench, near its outer edge, to receive the back end of the shears, and at the proper angle, so that the front or blade part of the shears will be the proper hight for working.

In cutting out the work cut the circle part first, as this enables the three pieces to be held together by the lugs at each end until the straight sides of the pattern are cut away and properly notched, as shown in Fig. 75. In commencing to cut out the work begin at the bottom of the sheet and cut away the circle *a*, as shown

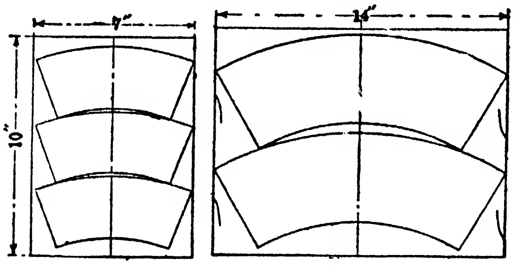


Fig. 74. Marking the Patterns on the Tin

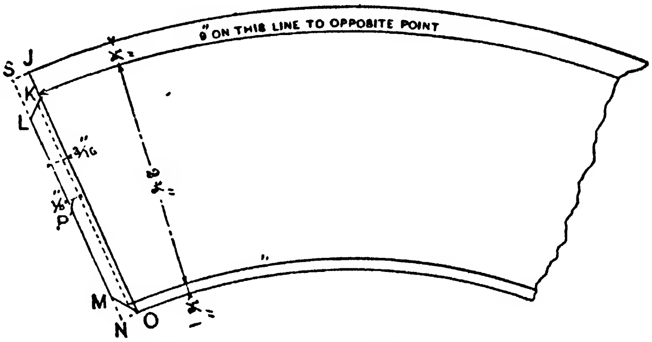


Fig. 75. Allowing Laps and Notching

in Fig. 73; then the circle *b*, and then all the other circles shown on the sheet up to *h* and inclusive. Leave the three pieces in each of the four sections intact until the ends with lugs are cut off and properly notched, as shown in Fig. 75. Referring to Fig. 75, the notching of the end of the patterns is sufficient in width for the take-up of the seams, 3-16 inch, as shown by S J. Make J K 5-16 inch. Then cut away S J K L and the correct notching is obtained of the top of the pattern for the wire. At the bottom cut away the point M N O on a slant of 45 degrees, making the distance N O the same as S J, or 3-16 inch in width. The size or width of lock is two-thirds the width of the cut-away S J and N O—3-16 inch—and hence must be 1/8 inch, as shown by the dotted line at P.

The same process is carried out in cutting out the patterns for the 3-pint and 2-quart basins as for the 1-pint basin. Referring to the 3-pint basin in Fig. 72, it is found that the best size for the patterns to cut stock most economically is as shown, with two pieces of the B size pattern and one of the C size. Four pieces of the B pattern cut out of a 10×14-inch sheet of tin, as shown in Fig. 73. Three pieces of the C pattern cut out of a 7×10-inch sheet of tin, as shown in Fig. 74, or six pieces out of a 10×14-inch size. Sometimes when cutting out this latter pattern, instead of notching for lugs at each side of the sheet, as in the other patterns, the 10×14-inch sheet of tin is doubled together in the center of the 14-inch side of the sheet, thus making the side notching of the sheets unnecessary, as

the folded edge on the one side holds the parts together until the work is cut out, leaving the folded end of the sheet as the last to be cut.

As will be observed in referring to Fig. 72, which shows the profile of a 2-quart basin, it requires two pieces of pattern D. These cut out of a 10×14-inch sheet of tin, but two pieces out of the long or 14-inch way of the sheet, as shown in Fig. 74.

The bottom for a 1-pint basin is cut 4¾ inches in diameter; the bottom for a 3-pint basin is cut 7 inches in diameter, and the bottom for a 2-quart basin is cut 6⅞ inches in diameter.

PATTERNS FOR FLARING ARTICLES

The following patterns are for some of the many articles that are laid out by the conical method; among which is a flaring washbowl, such as is shown in Fig. 76, usually made from two pieces, with a wired edge at the top and a straight rim stand at the bottom. It is made from IC or IX bright tin plate, with locked seams. The method of obtaining the pattern is shown in Fig. 77, in which E J H I is the half-pattern. The pattern for the bottom is a circle struck with a radius

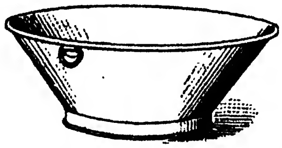


Fig. 76. Finished View of Bowl

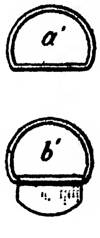


Fig. 78. The Ring

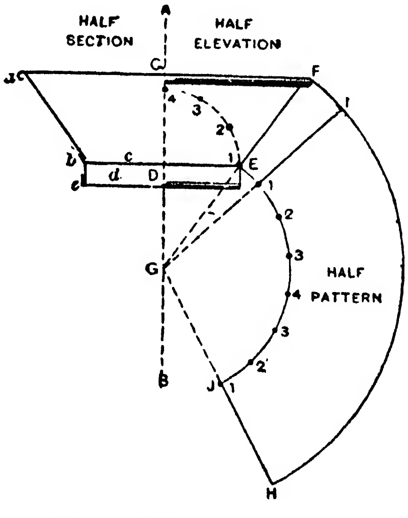


Fig. 77. Elevation and Pattern

equal to D 1, while the pattern for the lower rim is as high as shown, with a hem edge allowed equal in length to four times the quarter plan D 1 4.

To the left of the center line is shown the method of construction. The body has a wire edge at *a*, while the bottom *c* has a single edge, *b*, to which the body is soldered. The rim *d* has a hem edge at *e*, soldered raw edge to the bottom *c*. The

wire ring shown in Fig. 76 is made as shown in Fig. 78, in which *a'* represents the wire ring, while in *b'* the wire ring is shown with the clip attached, which is soldered to the body, allowing the ring to turn.

In the accompanying illustration, Fig. 79, is shown the method of obtaining the pattern for a round dish pan, which can be made in two or more pieces of IC or IX

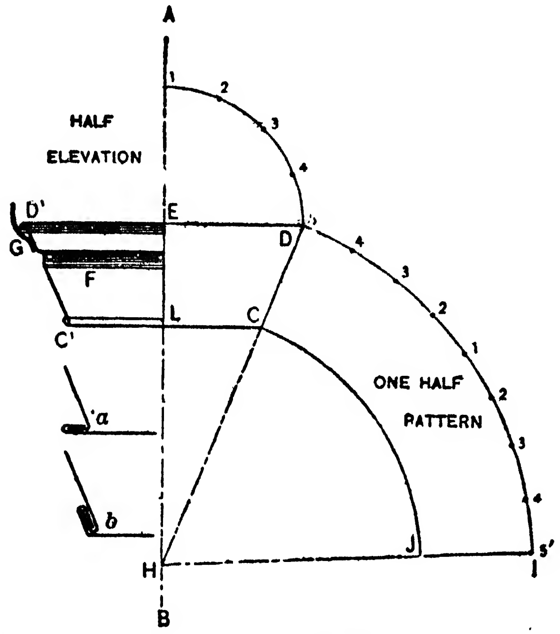


Fig. 79. Round Dish Pan

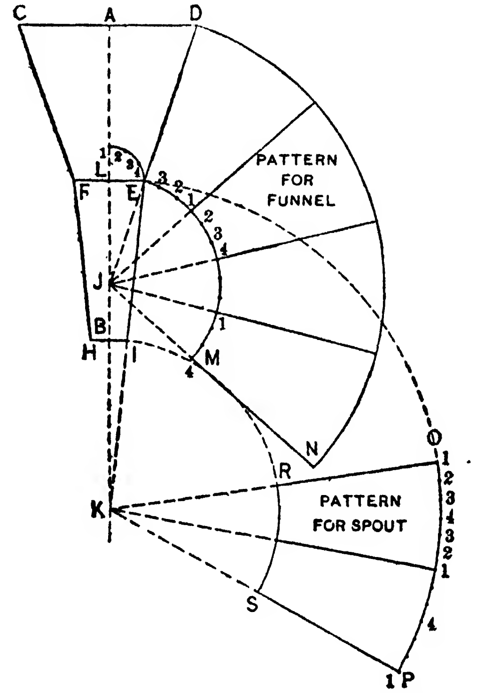


Fig. 80. Pattern for Funnel and Spout

Fig. 81. Perspective View

Fig. 83. Handle Pattern

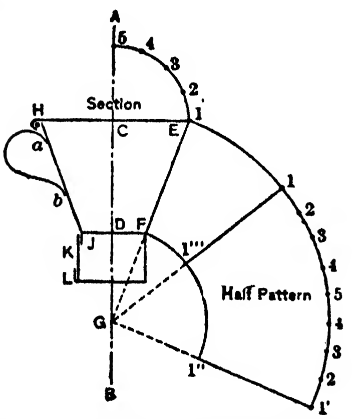


Fig. 82. Obtaining the Half Pattern

tin with grooved seams, the pattern of which, C D J I, is the one-half pattern for the dish pan. The bottom to the pan is double seamed. The first operation is shown by *a*, the second and final operation by *b*. D^1 E L C^1 shows a half elevation of the finished pan. Using the small beader, a bead is placed as at F. Tinned iron handles are riveted in position, as at G, and a wired edge is made at the top.

Another article is a funnel with spout, the drawing being made to avoid unnecessary lines and to simplify the work as much as possible, as shown by Fig. 80, in which both the funnel and spout are

developed similarly. The spout should have creases in it to allow the air to escape from a vessel that is being filled. These creases are best made, after the spout is formed into shape, by slipping over a suitable tool with grooves cut in it and dressing the metal of the tubes into these grooves with the peen of the hammer.

A simple piece of tinware which can be rolled up and soldered in spare time is a fruit jar filler, a finished view of which is shown in Fig. 81. These fillers are usually made from IC bright tin with locked seams and wired edge. The methods of construction and for obtaining the pattern are shown in Fig. 82; and the handle pattern is demonstrated in Fig. 83.

An article which can be made up for stock in different sizes is a dairy pail, shown in Fig. 84. It should be made of bright IC or IX tin, the body made in two pieces, and the bottom double seamed to the body. The ears are of malleable iron riveted to the body. The pails can be made with wooden handle on iron bail or with iron bail only. An ogee swedge may be turned near the upper part of the body, as shown in Fig. 85, which makes a neat appearance and strengthens the pail, and in which H I J K is the half pattern for the pail, to which allowance must be made for seaming and wiring, and with the bottom laid out with a radius equal to D E, strike the pattern for the bottom, shown by O P, to which edges have been allowed for double seaming at *a* and *b*. To the left of the line A B is shown the construction. L represents the wired edge, M the ogee swedge and N the doubled seams between the bottom and body.

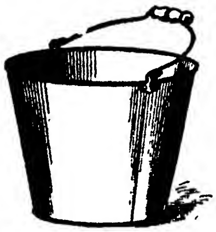


Fig. 84. Finished View of Pail

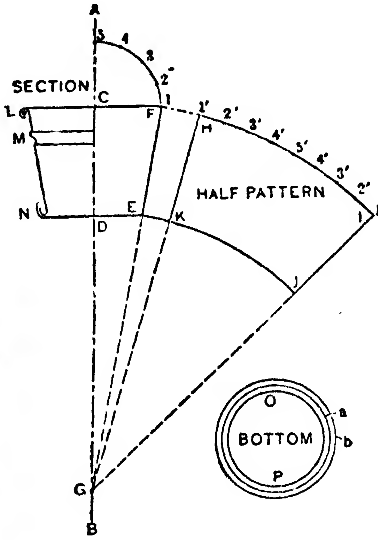


Fig. 85. Section and Patterns

A sap bucket with a hole at A for hanging it upon a support is shown in Fig. 86. The upper edge is wired at B and the bottom soldered or seamed at C. In Fig. 87 is shown how to develop the patterns. Laps are allowed on the sides for seaming and at the top for wiring. D in elevation shows the section of the wire, and C the edge of the bottom to be soldered to the body. With radius equal to *a* B, describe the disk F, to which an edge is allowed, as shown. A hole is punched in the pattern at 1, which is similar to A in Fig. 86. These buckets are usually made of IX tin.

When a flour sifter is to be constructed similar to the one shown in Fig. 88, the wire cloth *c* is usually brass or tinned wire, and ⅛-inch thick rods (tinned) are

usually placed under the wire cloth to stiffen it, as indicated by the heavy lines *a* and *b*. The edge *d* is wired, and *e* is a groove in which the wire cloth is fastened by soldering. Of course, a better method of fastening the wire cloth to the body of the sifter, is to turn a small edge on the body, using the burr machine for this purpose, also turning an edge on the cloth. It is possible to turn this edge on the cloth, because it possesses sufficient stiffness; the cloth is now slipped on the body, the edges squeezed tight in the setting down machine, and this edge is double seamed by placing the sifter on the mandrel and throwing down the edge with a mallet. If the seam has a rounded appearance it is squared by inverting the sifter, and holding the edge of the seam on a square head stake, the seam is dressed with a mallet.

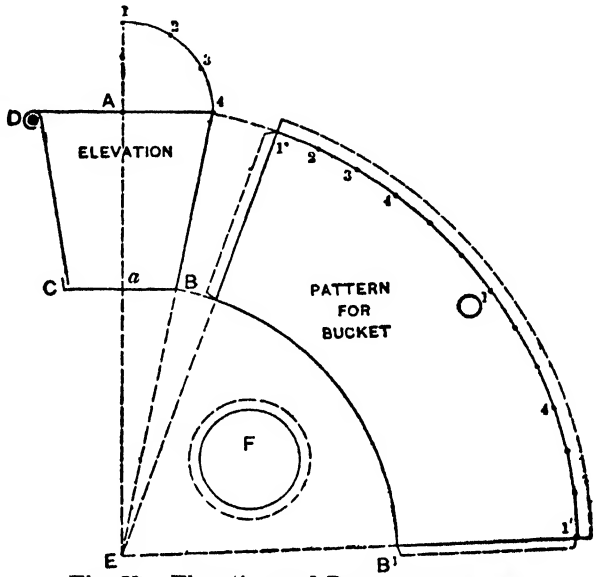


Fig. 87. Elevation and Pattern for Bucket

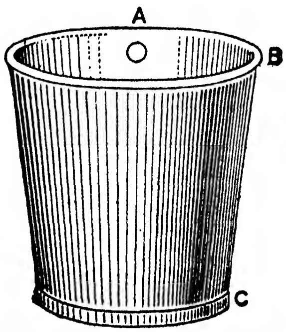


Fig. 86. View of Sap Bucket

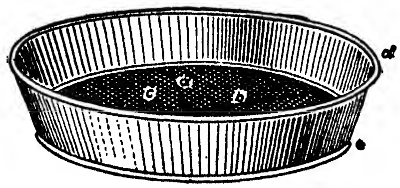


Fig. 88. Flour Sifter

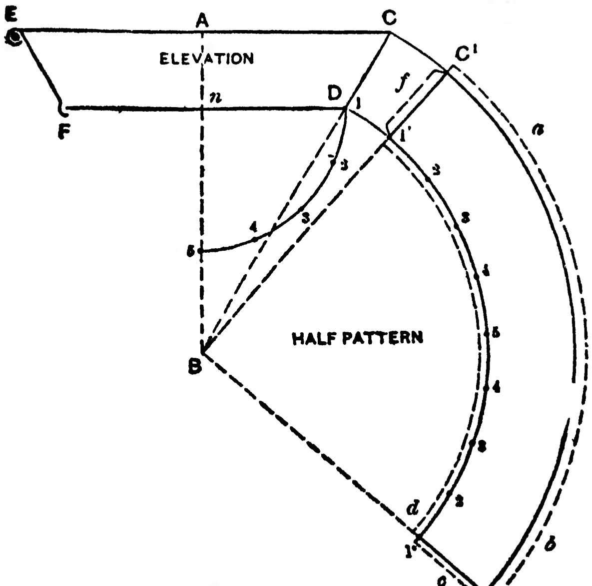


Fig. 89. Pattern for Flour Sifter

The pattern is obtained in the same way as the patterns for all flaring ware, as shown in Fig. 89. C^1 C^2 1° 1′ is the half pattern for the body of the sifter. An edge is allowed at *a b* for wiring E in elevation, also an edge along *e d* in the pattern for the groove or swedge F in elevation. The letters *c* and *f* are side seams.

PATTERNS FOR MILK STRAINER

The various forms of milk strainers are usually attached direct to the pails known as milk buckets or strainer pails. In Fig. 90 is shown a simple form of milk strainer placed directly over the can, and forming a cover which keeps out dust or insects until the can is filled and the cover replaced. In this cut A represents the upper portion of the milk can, broken at B to show a sectional view of the strainer C. It will be noticed that the edges are wired at *c c* and *d d*. The upper flaring piece, *c c* joins the lower flaring piece *d d*, forming a cover, which sets over the can, as shown. The inner cone, or strainer, *a b*, is soldered to the lower flaring piece, and has four circular holes cut into it in proportion to its size, about the same as shown in pattern M in Fig. 92. Over these holes, as shown by *a* and *b* in Fig. 90, fine wire cloth is soldered. The holes are cut above the apex of the cone, so that the sediment or dust, etc., has a chance to settle, and does not interfere with the straining of the milk.

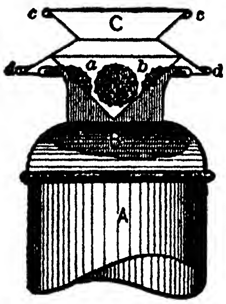


Fig. 90. Milk Strainer in Position

In Fig. 91, first draw the half elevation opposite the center line A B, as shown by C D E F G H I J K. Extend the sides D E and H E until they

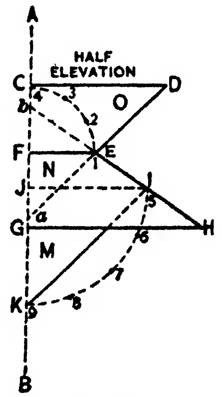
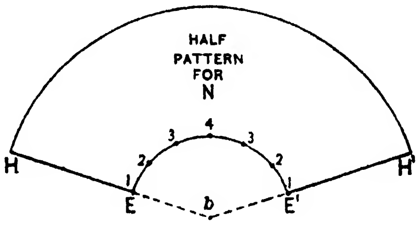
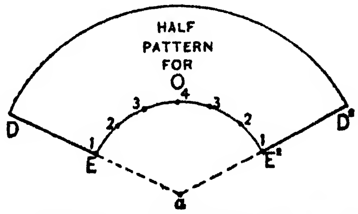


Fig. 91. Half Elevation and Radii





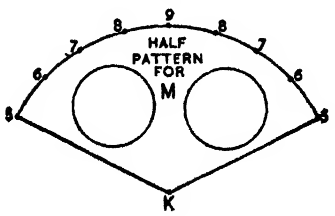


Fig. 92. The Pattern Shapes

intersect the center line A B at *a* and *b*. With F as center and F E as radius, describe the quarter plan on that line, as F E 4, which divide into equal parts, as

shown by the small figures 1, 2, 3 and 4. In similar manner, with J as center and J I as radius, describe the quarter plan J I 9, which also divide into equal spaces, as shown from 5 to 9. For the pattern for the inner cone, or strainer, M, use K I as radius, and, with K in Fig. 92 as center, describe the arc 5 5, on which lay off the stretchout of twice the number of spaces contained in the quarter plan 5 9 in Fig. 91, as shown from 5 to 9 to 5 in Fig. 92. Draw lines from 5 to K. Having done this much, K 5 9 5 K will then be the half pattern for the part designated M in Fig. 91.

At pleasure, draw two circles in the pattern M in Fig. 92, which cut out, and over the same solder circular pieces of tinned brass wire cloth. With radii equal to *b* E *b* in Fig. 91 and *b* in Fig. 92 as center, draw the arcs E E^1 and H H^1, respectively. From *b* draw any line, as *b* H, intersecting the inner arc at 1. Take the stretchout of the quarter circle 1 4 in Fig. 91 and place twice this amount on the arc E E^1 in Fig. 92, as shown from 1 to 4 to 1′. From *b* draw a line through 1′, intersecting the outer arc at H^1. Then will H H^1 E^1 E be the half pattern for N in Fig. 91. In a similar manner obtain the half pattern for O in Fig. 92, using the radii *a* E, *a* D in Fig. 91, and place twice the stretchout of the quarter plan 1 4 on the arc E E^2 in Fig. 92. Then will D D^2 E^2 E be the half pattern for O in Fig. 91.

PATTERNS FOR A DUST PAN

For a square cornered dust pan, the method for cutting the patterns is not difficult, and is as follows:

In Fig. 93 let A B C represent the side of the pan, and D E F G the view of the bottom on the line A C in side view. It is now necessary to obtain the miter line of the corners in the plan. With F in the plan as a center, describe the arc H I, so as to intersect the sides of the pan G F at H and F E at I. Then, with H and I as centers, and with any convenient radius, describe the arcs K and J respectively, intersecting each other at L. Also through L and F draw a line, extending it outward toward M. Intersect this by a line projected from the point B in side view. From M draw a line to G, thus completing the side of the pan in plan, as shown by G F M. In similar manner draw the opposite side D E N.

In the side view draw O P, the center line of the handle, so as to intersect the bottom of the pan and also the back at Y. At right angles to O P, draw the

line R S of the proper dimensions, and from R and S draw lines to the center O, intersecting the back and bottom of pan at Z and T and the bottom at C, respectively. To obtain a view of the handle in plan, which, however, is not necessary in the development of the pattern, proceed as follows: Through the center of the pan draw the line U V, then from the points O, T, R and S in

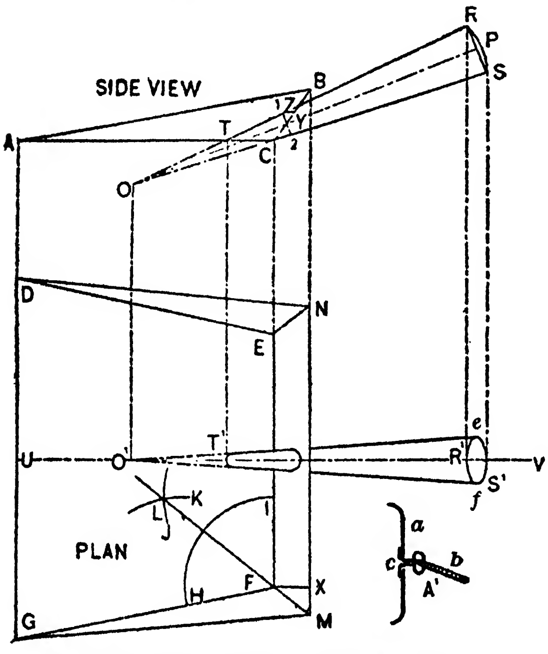


Fig. 93. Plan and Side View of Dust Pan

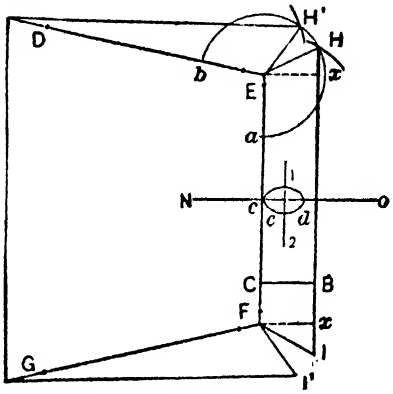


Fig. 94. Pattern for Pan

side view, drop lines intersecting the center line in plan at O^1, T^1, R^1 and S^1. Now take the distance from P to R in side view, and place it in plan, as shown on either side of the center line by *e* and *f*, and from these points draw lines to the center point O^1. The solid lines shown give the plan view of the handle.

For the pattern for the pan take a tracing of D E F G and place it as shown by D E F G in Fig. 94. Now take the distance from C to B in side view in Fig. 93, and place it as shown, at right angles to E F in Fig. 94 by C B. Through B, parallel to E F, draw the line H I. At right angles to E F, and from points E and F draw the lines E *x* and F *x*. Also take the distance from X to M in plan in Fig. 93, and place it as shown from *x* to H and *x* to I in Fig. 94, and draw lines from H to E and I to F. Now, with E as center and E H as radius, describe the arc *a b*. With *a* H now as radius and *b* as center, intersect the arc *a b* at H^1. Draw lines from E to H^1 to D. Trace similar miter on the opposite side, as shown by F I^1 G. Then will D H^1 E H I F I^1 G be the pattern for the pan.

Referring to the side view in Fig. 93, it will be noticed that the handle passes through the back of the pan and is soldered to the bottom at T C. For the opening to be cut into the back of the pan proceed as follows: Bisect the line E F

in Fig. 94 by N *o*, then take the distance from C to Z in side view in Fig. 93, and place it as shown on the line N *o* in Fig. 94, from *c* to *d*. Bisect *c d* and obtain the point *e*, through which, at right angles to *c d*, draw 1 2 indefinitely, as shown. And, at right angles to O P in side view in Fig. 93, and through the intersection Y, draw a line intersecting the sides of the handle at 1 and 2. Now take the distance from Y to 1 or 2 and place it in Fig. 94 from *e* to 1 and *e* to 2. Through 1 *d* 2 *c* draw the ellipse, through which the handle will pass.

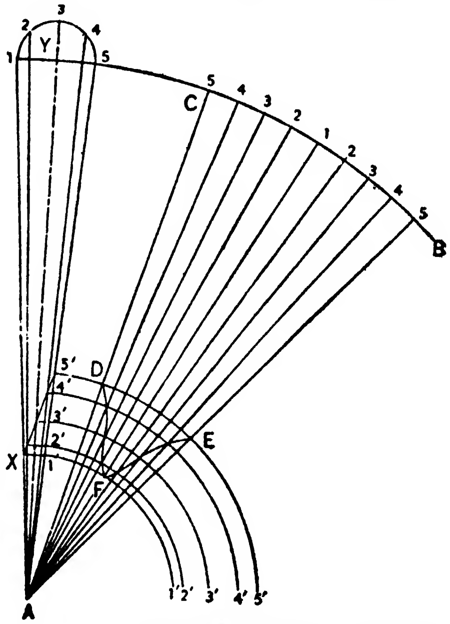


Fig. 95. Pattern for Handle, Enlarged

In Fig. 95 is shown the method of obtaining the pattern for the handle, which has been drawn on a slightly enlarged scale to better show the principle. Let A 5′ 5 1 *x* be a reproduction enlarged, of Q C S R T in side view in Fig. 93. Place the semicircle 1 3 5 at the end of the handle in Fig. 95, which divide into equal spaces, as shown by the small figures 1 to 5. From these points, at right angles to 1 5, drop lines intersecting the base line 1 5, as shown. From these intersections draw lines to the apex A, intersecting the line X 5′, as shown. From these intersections, at right angles to the center line 3 A, draw lines intersecting the side of the handle 5 A at 1′ to 5′, as shown. Now with A as a center and radii equal to A 5, A 5′, A 4′, A 3′, A 2′ and A 1′, draw arcs, as shown. Draw any radial line, as C A. From C on the arc C B step off twice the number of spaces shown in the semicircle Y, as shown by the small figures 5 to 1 to 5 on C B. From these points draw lines to the center A, intersecting arcs having similar numbers, as shown. Trace a line through these intersections, as shown by D F E. Then will C B E F D be the pattern for the handle.

P in Fig. 93 shows a button on the handle slightly raised, on which a wire ring can be fastened to hang up. The wire ring can be fastened as shown in diagram A[1], Fig. 93, in which *a* is the raised button, *b* the wire ring, around which a strip ¼ inch wide, shown by *c*, is fastened. A slit ¼ inch wide is cut into the button with a small chisel, the strip passed through and turned over, as at *c*, which completes the pan. The corners are double seamed, or riveted and the edge wired or hem-edged.

PATTERNS FOR A SPONGE BATH

In Fig. 96 is shown a perspective view of a sponge bath, with seat, sponge holder and foot braces A and B. Baths of this kind are usually made from galvanized iron or heavy tin plate, or from zinc, which will not rust or tarnish.

In Fig. 97 is shown a half elevation, also a half sectional view, as well as the various patterns. Whatever size bath is required, draw the details and patterns by first drawing the center line, A B, upon which place the hights of the different flares, as shown by C D E. On either side of the center line A B, from the points C D E, place the semidiameters of the bath, as shown by H J, G K and F L. Then E F H C shows the half elevation, while E L J C shows the half sectional view, with wire edge at L, and edges at K and J for soldering purposes. L M shows the flare of the splash shield, which goes only a part way around the bath, as indicated in plan by *b* M^1 *c*. By N O L is shown the section of the foot brace, which can be made from the band iron which holds the galvanized iron sheets. One-half the plan of the bath is shown below the sectional view, the semicircles being struck from the center P, which represent the projections of the various flares, as shown by the dotted lines. By *a b c d* in plan is shown the seat, represented in the sectional view by *e* L K. By *h i j k* in plan is shown the sponge holder, while similar figures on the opposite side, or S H, show the soap holder, both being represented by *m l* L.

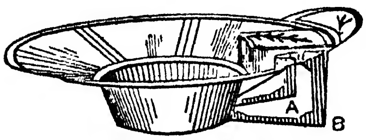


Fig. 96. The Sponge Bath

The pattern for the bottom of the bath is simply a circle with a radius equal to C H in elevation, allowing edges for soldering. For the pattern for the lower flare G H, extend this line until it meets the center line A B at R. With R as center, and R H and R G as radii, draw the arcs H^1 H^2 and S^1 G^1. Draw any radial line, as S^1 R, intersecting the inner arc at H^1. Now with D in the half elevation as center, and D G as radius, draw the quarter circle G S, which space into equal parts, as shown from 1 to 5, and transfer these spaces to the outer arc S^1 G^1 as shown, and draw the radial line from G^1 to R, cutting the inner arc at H^2. S^1 H^1 H^2 G^1 is the one-quarter pattern for the lower flare, the dotted lines being edges for seaming.

The pattern for the upper flare is obtained in a similar manner. F G is extended until it intersects the center line at T. Then, using T as center and T G and T F as radii, the arcs S^0 G^0 and F^1 F^2 are struck. On the inner arc, S^0 G^0, the girth of the quarter circle G S is placed. Radial lines are now drawn from T through S^0 and G^0, extending them until they intersect the outer arc at F^1 and F^2, respectively, which completes the one-quarter pattern for the upper flare, the dotted lines representing the edges.

For the pattern for the splasher shield extend M L in the sectional view until the center line A B is intersected at U. Then, with radius equal to U L, and U° as

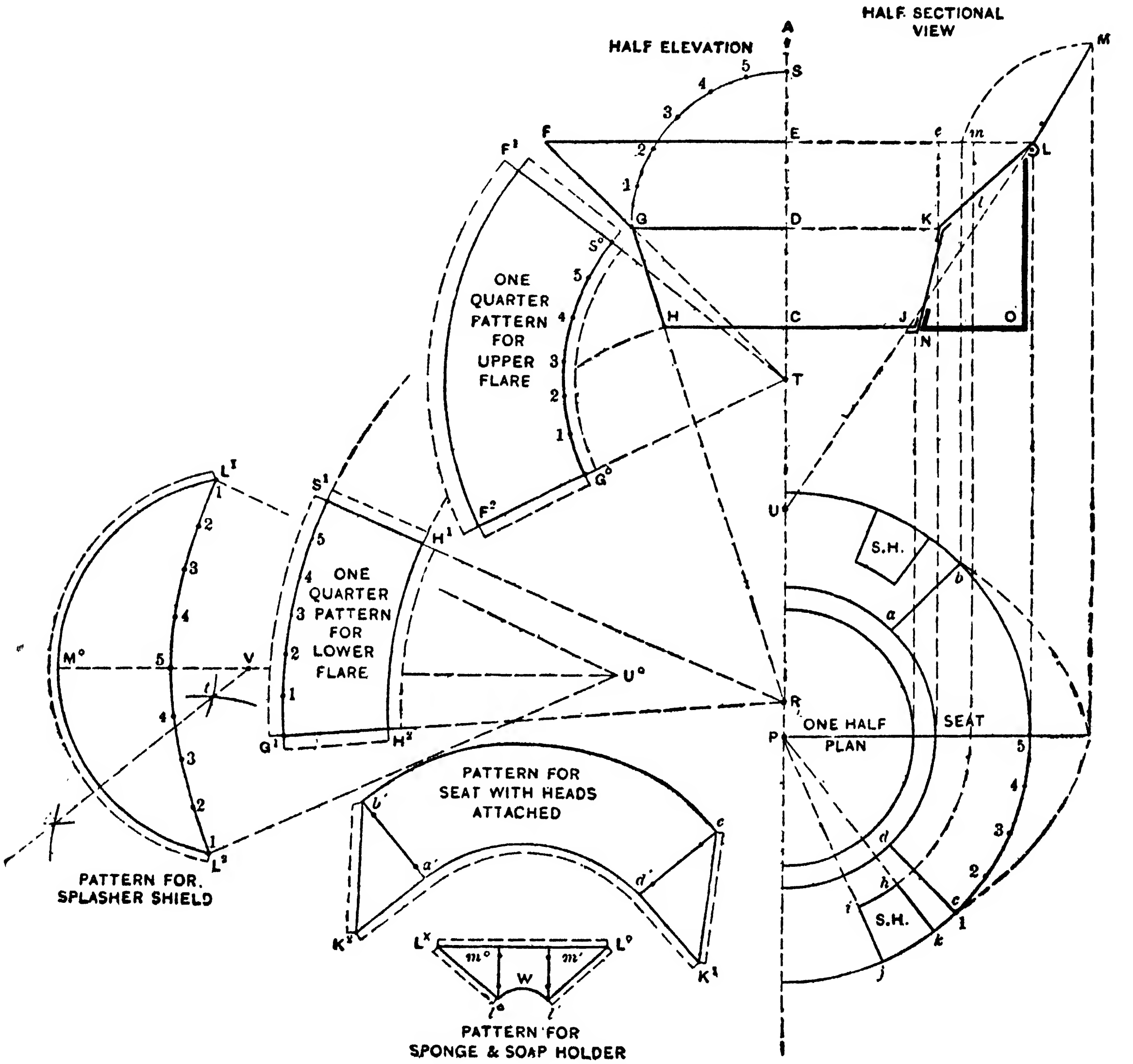


Fig. 97. Elevation, Plan, Section and Patterns

center, describe the arc L^1 L^2. As the shield is only to continue as far as from *b* to *c* in plan, obtain the girth of one-half of *b c*, or from 1 to 5, and place it as shown, from 1 to 5 to 1 on the arc L^1 L^2. Take the hight of the plane L M, in the sectional view, and place it on the line U° 5 extended, as shown from 5 to M°. With M° and L^2 as centers, and with radius more than half this distance, describe arcs, intersecting each other at *r* and *t*. Draw a line through *r* and *t* until it cuts the line U° 5 at V. Using V as center and V M°, or V L^2, as radius, describe the arc L^2 M° L^1, giving the pattern for the splasher shield, dotted lines being edges.

Take a tracing of the seat $a\ b\ c\ d$ in plan and place it as shown by $a'\ b'\ c'\ d'$. On $c'\ d'$ and $b'\ a'$ and the heads K^1 and K^2, which are reproductions of L e K in the sectional view. In practice a wooden board is placed inside the seat, and a square bend made along $b'\ a'$ and $c'\ d'$, then, if desired, the front of the seat, shown by e K in the sectional view, is soldered in position, with a width equal to e K, and length equal to the girth of $a'\ d'$ in the pattern for seat. Edges are allowed for soldering, as shown. For the pattern for the soap and sponge holder take a tracing of $m\ l$ L, in the sectional view, and place it as shown by $m'\ l'\ L^{\circ}$. Reverse this as shown by $m^{\circ}\ l^{\circ}\ L^{x}$, making $m^{\circ}\ l^{\circ}$ parallel to $m'\ l'$, and the distance between equal to $h\ i$ in plan. This leaves the top of the holder open when formed up, as shown at a in Fig. 96. To allow the drip to run off, a curve is cut in Fig. 97, as shown at W. Edges along $L^{x}\ L^{\circ}$ are for wiring and soldering.

CONSTRUCTION OF A HOUSEMAID'S PAIL

The rule given in connection with the sponge bath in the preceding article can also be applied in developing the patterns for the housemaid's pail shown in perspective in Fig. 98. It will be noticed that the flaring pail A sets inside the flaring vessel B to prevent any overflow; C is an open tube to receive the brush, and D is a holder for the soap. These pails can be made from black iron, seamed and riveted and then galvanized after they are made. Fig. 99 shows the construction between the pail and dish, while A shows the horizontal section of the brush and soap holder, which are riveted to the pail. In turning the edges for the bottom on both the guard and the pail, it is necessary to first place the guard on the pail and turn both edges at one time. By using a stake that will fit tight in the guard, edges can be double seamed if desired.

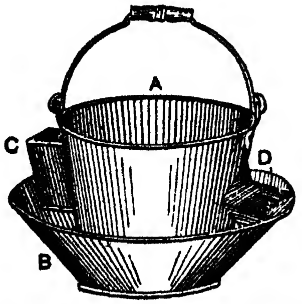


Fig. 98. View of Housemaid's Pail

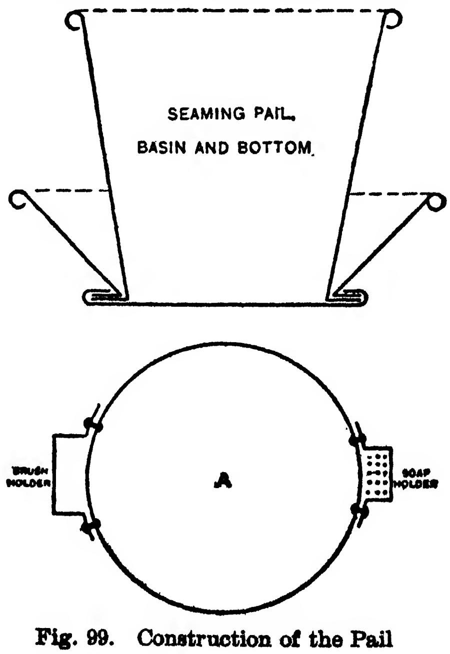


Fig. 99. Construction of the Pail

PATTERNS FOR TIN CHURN

In Fig. 100 is given a perspective view of a churn, in which A is the body, B the inverted cone cover, C the handle of the churners and D the churners, while *a* and *b* are cross pieces with perforations to better churn the contents in the up and down motion of the churner. This churn is best made from heavy tin plate, for the consensus of opinion is that zinc, or any galvanizing, affects such fluids as milk.

For the patterns for the various pieces proceed as is shown in Fig. 101, which is applicable to any size of churn. First draw the center line A B, upon which lay off the hight of the churn, as shown by *n m*. Then lay off the top and bottom diameters, F E and D C, respectively, and extend the sides D F and C E until they meet and intersect the center line at *b*. Now draw the bottom G, which make slightly concave, seaming it to the body at *a* and *a* and raising the bottom G on the wood block with the raising hammer. Also draw the cover H I J K in the form of an inverted cone, soldering a small tube in the center, as L M, to allow the handle S to work easily when churning. A double edge is allowed at P and R, to which the rim N O is seamed, fitting tightly into the top of the body, which is stiffened by the wire edge F E.

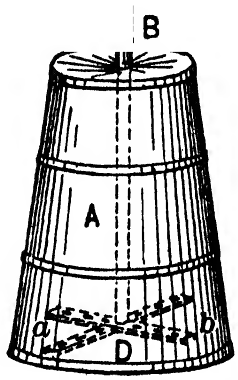


Fig. 100. Perspective View of Churn

By making the cover in the shape of an inverted cone, any fluid which escapes while churning flows back again into the churn through the tube L M. Extend the sides of the cover, I J and H K, until they meet and intersect the center line at *c*. Now, with *m* and *n* as centers, and radii equal respectively to *m* C and *n* I, draw the semicircles C 5 D and 1 4′ H, both of which divide into equal spaces, as shown respectively, by points 1 to 9 and 1′ to 7′. Then, with *b* as center and radii equal to *b* C and *b* E, describe the arcs C 9 and E U, and starting at any point, as 1, step off on the arc C 9 the stretchout of the semicircle D 5 C, as shown by similar figures on C 9. From 1 and 9 draw radial lines to the apex *b*, which intersect by an arc struck from *b* as center and *b* E as radius, thus locating the points T and U. Then will T U 9 1 be the half pattern for the body of the churn, to which laps are allowed for seaming and wiring, as shown.

For the pattern for the cover use *c*′ in X as center, and with radii equal to *c* J and *c* I in the sectional view, describe arcs in X, as shown by K^1 J^1 and 1′ 1″. Take the stretchout of the semicircle H 4′ I, and starting at any point, as 1′ on the outer arc in X, step off twice this amount, as shown from 1′ to 7′ to 1″.

From points 1′ and 1″ draw radial lines to c, intersecting the inner arc at K^1 and J^1. Then will K^1 J^1 1″ 1′ be the pattern for the cover, with laps allowed for double seaming.

W V in diagram Y shows a perspective of one of the churners, with double edges bent at *d* and *e* to stiffen the same. Holes are punched into the top, as shown, while X is the center hole, to which the metal tube C, in Fig. 100, is fastened. A wood bottom should be fitted under the bottom G in Fig. 101, also a heavy band iron hoop placed at the lower edge and top, also intermediate ones, as shown by Fig. 100, to secure stiffness, and especially the bottom one, prevent wearing of the body when moving the churn about. These hoops are made of ordinary band iron which is thoroughly tinned; and are secured to the body by riveting.

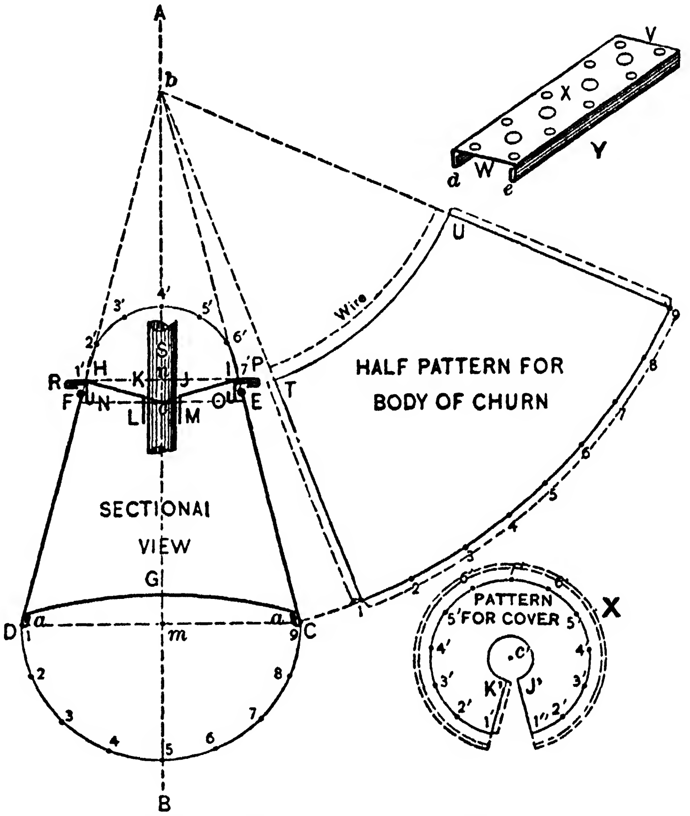


Fig. 101. Sectional Views and Patterns

PATTERNS FOR FLARING MEASURE WITH LIP

In Fig. 102 is shown a finished view of a lipped measure which requires four patterns—namely, the measure, lip, handle and grasp. These measures are usually made from bright IX tin, or copper tinned on the inside, usually the lip is wired at the top edge, also the top of the measure and the lip edged and simply soldered to body. The bottom is always double seamed on the body. Wire on both sides of the handle stiffen it and is riveted and soldered to the body.

As they must hold a given quantity and must be tested before they are sold, herewith is presented a table giving the hight, bottom and top diameters for different measures from 1 gill to 1 gallon:

Size	*Bottom Diameter, in Inches*	*Top Diameter, in Inches*	*Hight, in Inches*
1 gill	2.06	1.37	3.10
½ pint	2.60	1.73	3.89
1 pint	3.27	2.18	4.90
1 quart	4.12	2.75	6.18
½ gallon	5.18	3.45	7.78
1 gallon	6.55	4.35	9.80

Fractional Equivalents of Above
(Correct to $\frac{1}{32}$ in.)

Bottom Diameter in Inches.	*Top Diameter in Inches.*	*Hight in Inches.*
2.06—$2\frac{1}{16}$	1.37—$1\frac{3}{8}$	3.10—$3\frac{3}{32}$
2.60—$2\frac{19}{32}$	1.73—$1\frac{3}{4}$	3.89—$3\frac{29}{32}$
3.27—$3\frac{9}{32}$	2.18—$2\frac{3}{16}$	4.90—$4\frac{29}{32}$
4.12—$4\frac{1}{8}$	2.75—$2\frac{3}{4}$	6.18—$6\frac{3}{16}$
5.18—$5\frac{3}{16}$	3.45—$3\frac{15}{32}$	7.78—$7\frac{25}{32}$
6.55—$6\frac{9}{16}$	4.35—$4\frac{11}{32}$	9.80—$9\frac{13}{16}$

Assuming that a measure is to be made holding a given quantity, and knowing the size, first draw the vertical line A B in Fig. 103, upon which place the hight, as shown by *a b*. At right angles to A B, draw the top and bottom diameters, C D and F E, respectively, as shown. Extend the lines E D and F C respectively, until they meet the center line A B at A. At pleasure, draw the angle or flare of the front of the lip, as shown by *d* C, extending the line *d* C until it intersects the center line A B at *c*. From *c* draw a line through D and make D *e* equal to the hight of the back of the flare, which is established at pleasure, and draw a line from *e* to *d*. With *a* and *b* as centers, describe the half sections C 4′ D and F B E respectively, as shown, both of which divide into an equal number of spaces, as shown by points 1 to 7 and 1′ to 7′. At pleasure, draw the handle D *e f* J, and the grasp H.

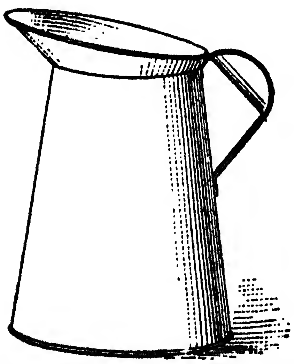


Fig. 102. Perspective View of Finished Measure

For the pattern for the measure use A as center, and with radii equal to A D and A E, draw the arcs E E^1 and D D^1. At any point, as F^1, draw a radial line to A, intersecting the arc D D^1 at C^1. Starting from F^1, lay off on the arc E E^1 the stretchout of the half circle F B E, as shown by similar figures on F^1 E^1. From the point 7, draw a line to the apex A, intersecting the arc D D^1 at D^1. Then will C^1 D^1 E^1 F^1 be the half net pattern for the measure.

For the pattern for the handle take a stretchout of D *e f* J and place it on the vertical line D^1 J^1, at right angle to which, through points D^1 and J^1, draw the top

and bottom width of the handle at pleasure, as shown by *m m* and *n n*, respectively. Draw lines from *m* to *n* on both sides; then will *m n n m* be the net pattern for the handle. The method for obtaining the pattern for the grasp H is shown in diagram U, in which N shows the side view of the grasp enlarged from H, and P the

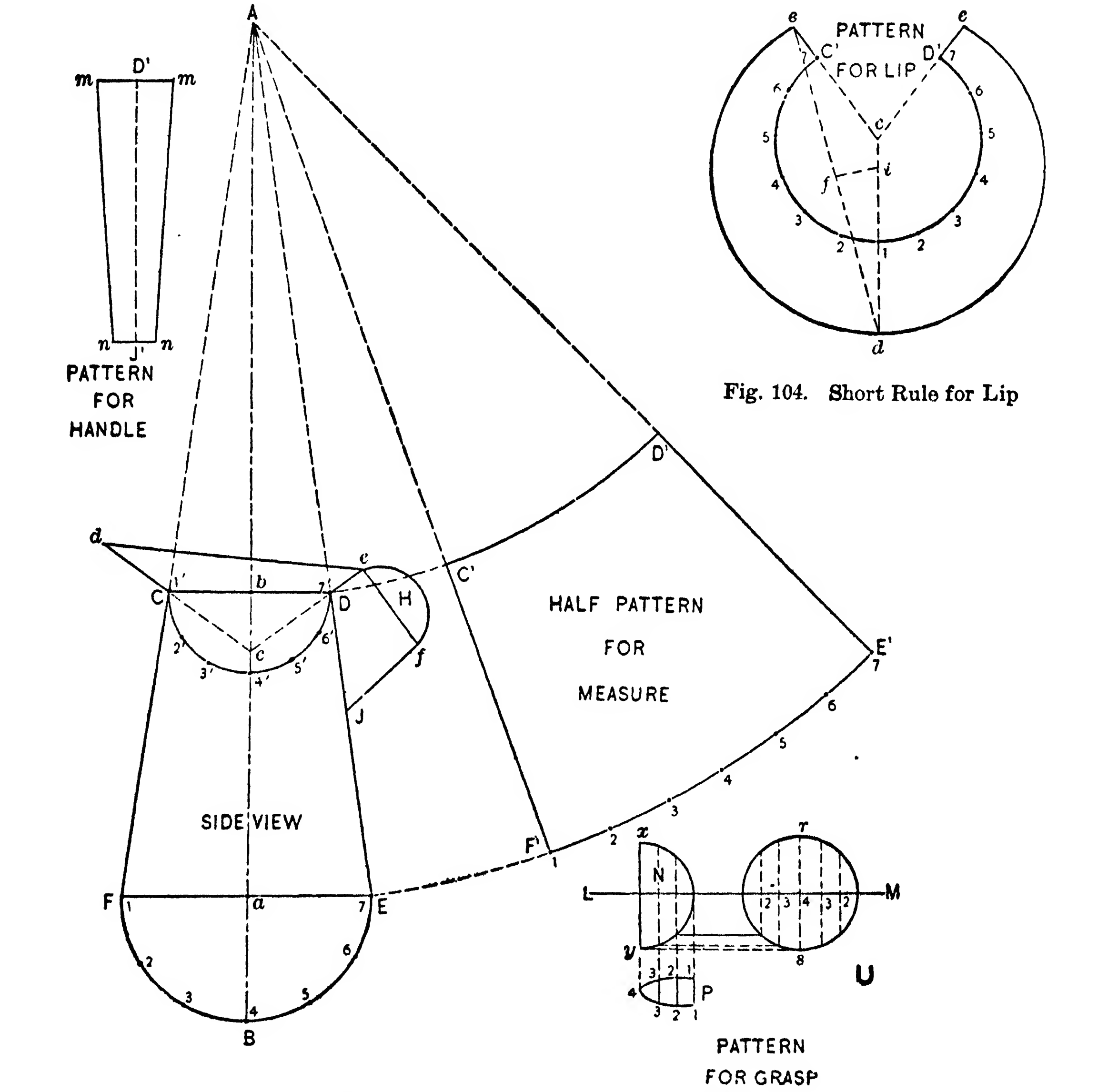


Fig. 104. Short Rule for Lip

Fig. 103. Elevation, Sections and Patterns

true section on the line L M, drawn through the center and at right angles to *x y*. Care should be taken to have distance 1 1 in section P no wider than the width of the handle at *f* in the side view. Divide the section P into an equal number of spaces, as shown by the points 1 to 4 on each side, from which, parallel to *x y*, draw

lines intersecting the curve of the grasp N, as shown. On the line L M lay off the stretchout of the section P, as shown by similar numbers on L M. Through these points, at right angles to L M draw lines, which intersect with lines drawn parallel to L M from similar intersections in the curve N. Trace a line, as shown by 1 *r* 1 *s*, which will be the net pattern for the grasp, edges not being necessary for soldering.

Although the lip *d* C D *e* in side view is a frustum of a right cone and can be developed by the cone method, a shorter rule which can be applied, and which answers the purpose just as well, is shown in Fig. 104. With radius equal to *c* D in Fig. 103, and *c* in Fig. 104 as center, describe the arc C^1 D^1. From *c* drop a vertical line *c d*, intersecting the arc just drawn at 1. Starting from the point 1, set off on either, the number of spaces contained in the half section C 4′ D in the side view in Fig. 103, as shown by similar numbers on the arc C^1 D^1 in Fig. 104. From *c* draw lines through the points 7 and 7, making 7 *e* on both sides equal to D *e* of the back of the lip in the side view in Fig. 103. Now take the distance of the front flare of the lip C *d* and place it, as shown, from 1 to *d* in Fig. 104. Draw a line from *e* to *d*, which bisect and obtain the point *f*. From *f*, at right angles to *e d*, draw the line *f i*, intersecting the center line *c d* at *i*. Then, using *i* as center and *i d* or *i e* as radius, describe the arc *e d e*, intersecting the radial lines *c e* and *c e* at *e* and *e*. Then will *e d e* D^1 1 C^1 be the net pattern for the lip; edges to be allowed for wiring and soldering to the body.

PATTERNS FOR A HIP BATHTUB WITH UPPER EDGE OF TUBING

A finished view of a hip bathtub is shown in Fig. 105. The material used in its construction is zinc or galvanized iron. Tubs made of black iron are usually enameled or japanned, with more or less stenciled or colored ornamentation; and those made of zinc are polished. In the illustration, *a a* is a flaring foot piece with a heavy wire edge, and *b b b* represents a heavy zinc bead placed along the top edge. Instructions are given farther on for making and applying this tubing; it is suggested however, that ordinary lead pipe would be equally advantageous for this purpose.

In Fig. 106 is shown how to obtain the pattern To do this first draw the center line J L, upon which place the hight of the bathtub, as shown from J to 5′. Through J and 5′ draw horizontal lines, making J D, J I and 5′ C, 5′ B equal respectively, to the half diameters of the top and bottom. In similar manner draw the side elevation of the foot G B C H. Draw a line from I through B, and from D through C, extending them until they intersect each other in the center line at L. In similar manner extend G B and H C until they meet at N. At pleasure draw the desired curve D E A, thus completing the side elevation. So much having been done, the next step is as follows:

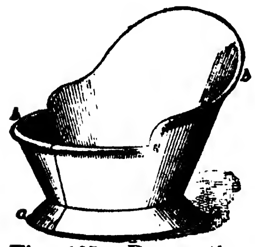


Fig. 105. Perspective View of Hip Bathtub

Using 5′ as center, with 5′ B as radius, draw the half bottom, or plan, B M C, which divide into equal parts, as shown from 1 to 9. From these points, at right angles to B C, draw lines intersecting B C at 1, 2′, 3′, etc. From the apex L draw lines through the intersections on B C until they intersect the upper

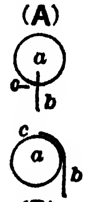


Fig. 108. Methods of Fastening Tube

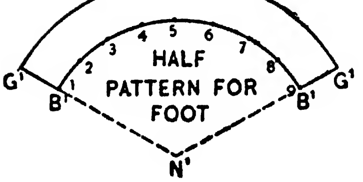


Fig. 107. Pattern for Foot

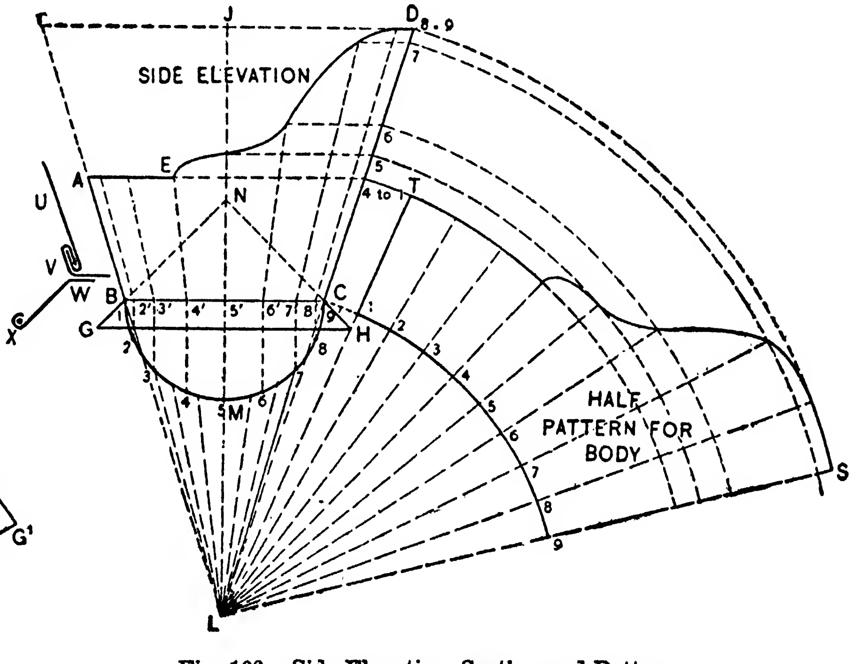


Fig. 106. Side Elevation, Section and Pattern

line of the tub A E D, from which points, at right angles to J L, draw lines intersecting D C at points 1 to 9, as shown.

Using L as center and with L C as radius, describe the arc H 9, upon which place the stretchout of the semicircle B M C, as shown from 1 to 9 on H

P. From L, through these small figures, draw radial lines, which intersect by arcs struck from L as center, with similarly numbered intersections on D C as radii. Through the points thus obtained, trace a line shown by H T S 9, which will be the half pattern for the body, to which edges must be allowed at the bottom for seaming to the body, as at V, and at the top for joining to the bead, as at (A) and (B) in Fig. 108. Also allow edge at T H in Fig. 106. B M C represents the half bottom, to which double edges must be allowed, as at V, for double seaming.

With radii equal to N B and N G, and with N^1 in Fig. 107 as center, draw the arcs G^1 G^1 and B^1 B^1. Take the stretchout of B M C in Fig. 106 and place it on the inner arc in Fig. 107, as shown. From N^1 draw lines through B^1 B^1, intersecting the outer arc at G^1 G^1, which completes the half pattern for the foot. Laps must be provided on the inner and outer arcs to allow respectively, for the flange W in Fig. 106 and the wire X.

The tubing for the upper edge of the tub is usually made from zinc. Knowing the diameter of the tubing, it is rolled up in straight lengths, lapped and soldered. One end is closed up, then the tubing is filled with hot white sand or melted rosin, after which it is formed to the required shape while warm. When the correct shape is obtained it may be fastened to the body, as shown in Fig. 108 in (A), by cutting a slot into the bead *a*, inserting the upper edge of the tub *b*, and then soldering at *c* on both sides. Another method is by flanging the tub *b* in (B), so that it lays snugly over the bead *a*; then soldering, etc., and scraping and sandpapering the upper edge at *c*. When the work is done it should present a smooth, clean surface. Under the bottom B C in Fig. 106, a wood bottom should be placed to stiffen it.

PATTERNS FOR COFFEE POT

It often happens that a customer desires some special piece of tinware made that is not kept in stock, such as a coffee pot of IXX tin. A perspective view of such an article is shown in Fig. 109. In developing the patterns, proceed as shown in Fig. 110. First draw any vertical line, as A B, upon which place the hight of the coffee pot, as B C. At right angles to B C, draw the top diameter D E and the bottom G F, placing one-half diameter of each on either side of the center line, as shown. Draw the lines D G and F E, extending F E until it intersects the center line A B at A. Then will A be the center point from which to strike the pattern. With B as center and B F as radius, draw the half plan of the bottom F 6 G, which

divide into equal spaces, as shown by the small figures 1 to 10. With A as center, and radii equal to A E and A F, draw the arcs J H and K I, as shown. From J draw a line toward the apex A, intersecting the arc K I at K. Starting from the point J, lay off on J H the stretchout of twice the amount of the half plan G 6 F, as shown by the small figures 1 to 10 to 1 on the arc J H. From H draw a line to the apex A, intersecting the arc K I at I. Then will I H J K be the pattern for the body of the pot.

Fig. 109. Perspective View of Coffee Pot

In its proper position draw the outline of the spout, as shown by L M N O, intersecting the body of the coffee pot D G at M and N, while L O represents the opening of the spout at the top. Extend the lines N O and M L until they intersect each other at P. Using P as center and P N as radius, describe the arc N 1′, which intersect by the line L M extended at 1′. Draw a line from N to 1′, which bisect and obtain the point *a*. Then, with *a* as center and *a* N as radius, describe the semicircle shown, which divide into equal spaces, as shown by 1′, 2′ and 3′. In practice, more spaces should be employed. At right angles to N 1′ and from 2′, draw a line intersecting N 1′ at *a*. From *a* draw a line to the apex P, intersecting D G of the pot at *b*, and O L of the top of the spout at *e*. Now, at right angles to the center line P *a*, and from the intersections at the bottom of the spout M *b* N, and at the top at L *e* O (which represent, respectively, points of intersections obtained from 1′, 2′, 3′ in the semicircle), draw lines intersecting O N of the spout at 1, 2, 3, at the top and bottom of the spout, respectively. Using P as center and radius equal to P N, describe the arc N S. At any point, as R, draw the line R P. Starting at the point R, set off twice the amount of spaces contained in the semicircle 1′ 2′ 3′, as shown by 3 1 3 on R S. From the points 3, 2, 1, 2, 3 on R S, draw lines to the apex P. With P as center and radii equal to P 3, P 2, P 1, P 1, P 2, P 3′, on O N of the spout, draw arcs intersecting radial lines of similar numbers, as shown. Trace a line through points thus obtained; then will *t u* S R be the pattern for the spout.

It will be noticed that the fact has not been taken into consideration that the spout intersects a round surface, but it is assumed that it intersects a plane surface, as D G. The difference in the pattern is so slight that it will not be noticeable in practice. Had the pattern been developed according to the true geometrical rule, it would present a problem of two cones of unequal diameters intersecting each other, and require a little time, while the short rule employed answers the purpose just as well where the spout is of so small a diameter.

For the pattern for the opening to be cut into the body to receive the spout, proceed as follows: From the point 10, or the center in the pattern for body, draw a line toward the apex A, intersecting the arc K I at 10′. From the intersections M *b* N between the spout and body, draw lines at right angles to C B, intersecting the opposite side of the body E F at M^1 b' N^1. Then, using A as center and

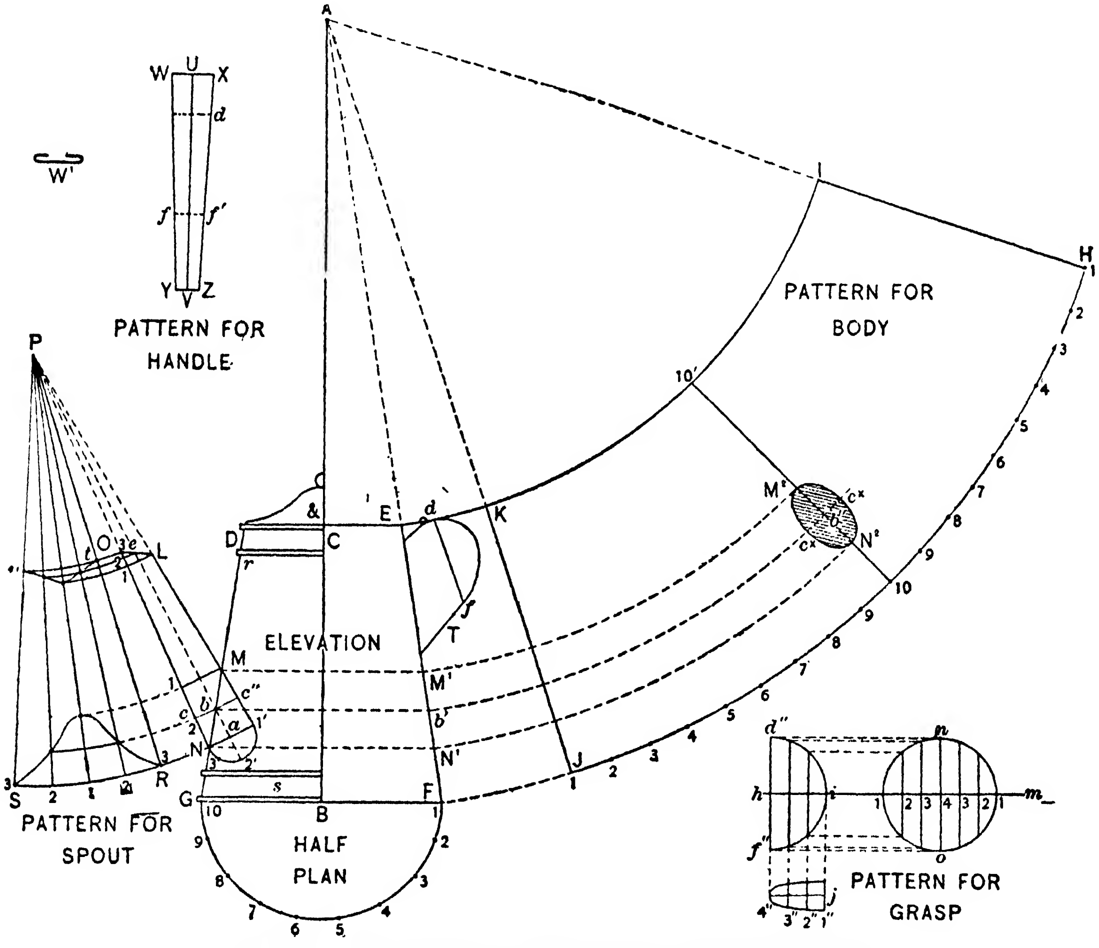


Fig. 110. The Pattern For Body, Spout, Handle and Grasp

with radii equal to A M^1, A b' and A N^1, draw arcs intersecting the center line 10 10′ of the pattern at M^2, b'' and N^2. Through b'', at right angles to 10 10′, draw the line c^x c^x. Through the intersection *b* between the spout and the body, and at right angles to the center line P *a*, draw the line *c* c'', intersecting the sides of the spout O N and L 1′ at *c* and c'', respectively. Take the distance of either *b* *c* or *b* c'', and place it as shown, in the pattern for body from b'' to c^x on either side. A line traced through the points M^2, c^x, N^2, c^x, will be the required opening.

After the body is rolled up and seamed, a bead, shown at *r* and *s* in elevation, can be put in to make a neat finish, and incidently stiffen the body. The bottom G F is seamed in the usual manner, while the cover & is a pitched cover, with hinge attached, and can be made by hand by raising with a hammer and the hollowed out block of wood. The little knob can be purchased in most any hardware store. It is to be understood that the customary rim is to be seamed to the cover.

A plain flat handle is shown by *d* T, which is laid out by drawing any vertical line, as U V, upon which lay off the stretchout of *d f* T of the handle. At right angles to U V draw W X and Y Z, the width respectively, of the top and bottom of the handle, and draw the lines W Y and X Z. Then will W X Y Z be the pattern for the handle, to which a hem edge, as shown at W^1, should be allowed.

The grasp is shown by *d f* in elevation, and in an enlarged view by $d'' f'', j$, representing the true section through *h i*. Care should be taken that the width of *j* is not more than $f f'$ in the pattern for the handle. Divide the profile *j* into an equal number of spaces, as shown by the small figures 1″ to 4″. From these points and at right angles to *h i*, draw lines intersecting the curve $d''\ i\ f''$, as shown. Extend the line *h i* as *h m*, upon which place the stretchout of *j*, as shown by points 1 to 4 to 1 on *i m*. At right angles to *i m* and through the small figures, draw lines, which intersect with lines drawn from points having similar numbers in $d''\ i\ f''$, at right angles to $d'' f''$. Trace a line through points thus obtained; then will *n* 1 0 1 be the pattern for the grasp. The letter *d* in elevation shows a small button which is soldered to the handle and prevents the thumb from slipping when in use.

PATTERN FOR RAISED BASIN

An article which is often required to be made up in copper, sheet iron or tin plate, is a raised basin, such as that shown in the finished view in Fig. 111. The wire hinge ring shown in the illustration is fastened to the basin by means of metal clip, as explained in previous articles. In getting out the pattern for the cove there is a certain rule, which, if followed, will bring the mold, when raised, to its proper desired dimensions at top and bottom, as shown in detail in Fig. 113. First draw the center line A B, upon which place the hight of the basin, as C D. From C and D draw horizontal lines, C E and D F, respectively, representing the half top and bottom diameters. With radius equal to *a* F, draw the cove F E, which completes the half elevation. Divide the cove F E into equal parts, as

shown by the small figures 1 to 7. Draw a line from F to E, which bisect and obtain *b*, from which point draw a line at right angles to F E, which will intersect 4 in the curve F E. From 4 draw a horizontal line, as 4 *c*, intersecting the center line A B at *c*.

The rule above referred to, to obtain true blanks for raised molds, was derived by experimenting extensively with various methods, rules and the like as adapted to circular cornice work. From these numerous tests it was found that the rule here presented is thoroughly practical and accurate. For additional information on raising work see Volume 6. Divide the distance from *b* to 4 into as many parts as the radius 4 *c* has inches. Any distance over ½ inch counts one, while of any distance less than ½ inch no account is taken. Thus, if the distance *c* 4 were 6⅝ inches, 7 would be taken; while if the distance were 6⅜ inches only 6 would be used. In this case, assume that the radius *c* 4 equals 4 inches. Then divide *b* 4 into four equal parts, as shown, and always through the first space *e* nearest the cove, draw a line parallel to F E, intersecting the center line A B at H, as G H. Now take the stretchout from

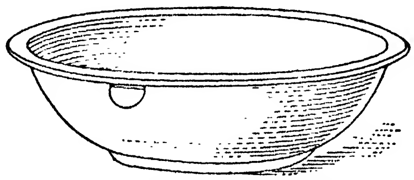


Fig. 111. Perspective View of Raised Basin

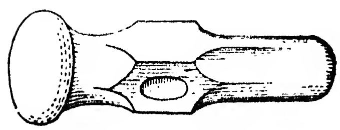


Fig. 112. Raising Hammer

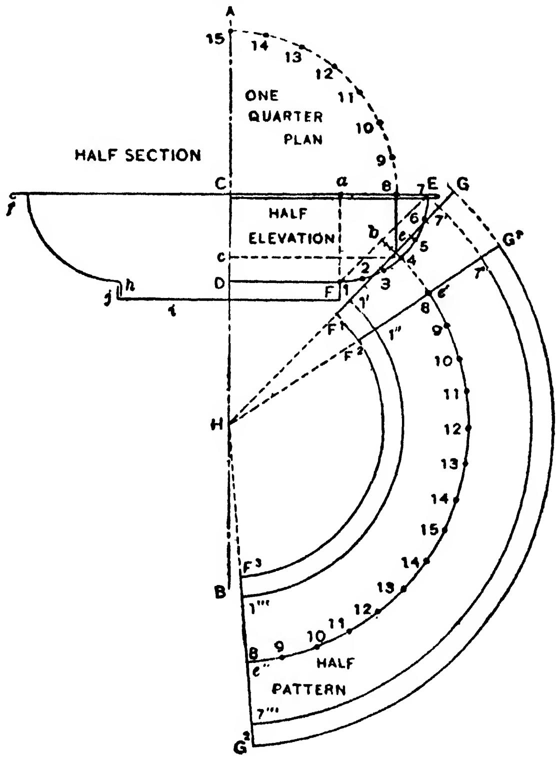


Fig. 113. Elevation and Pattern

4 to 1 and 4 to 7 and place it on the line G H, as shown respectively from *e* to 1′ and *e* to 7′. Then take the distance of the lower flange 1 F and the upper flange 7 E with the wire edge, and place it on the stretchout line G H, as shown respectively by 1′ F^1 and 7′ G. Then will G F^1 be the amount of metal required to form up by hand the mold E 4 1 F in the half-elevation. From the point *e*

erect a vertical line, intersecting the top line C E at 8; then, using C as center and C 8 as radius, describe the quarter plan 8 15, which is the quarter section on a horizontal line drawn from *e* in elevation. Divide the quarter plan into equal parts, as shown from 8 to 15.

For the pattern proceed as follows: Using H as center and radii equal to H F^1, H 1′, H *e*, H 7′ and H G, draw the arcs F^1 F^3, 1′ 1‴, *e e*″, 7′ 7‴ and G G^2. At any point on the outer arc, as G^1, draw a radial line to H, intersecting all the arcs drawn at 7″, *e*′, 1″ and F^2. Starting from *e*′, lay off on the arc *e*′ *e*″ twice the stretchout of the one-quarter plan, as shown from 8 to 15 to 8 on the arc *e*′ *e*″. From the center H draw a line through *e*″, intersecting the arcs previously drawn at F^3, 1‴, *e*″, 7‴ and G^2. Then will G^1 G^2 F^3 F^2 be the half pattern for the mold and flanges.

Before raising, the two halves are riveted together. They are then raised on the raising block, with a raising hammer of the required size, as shown in Fig. 112. When the mold is completed, it will be found that the top and bottom diameters are the desired size, resulting from the use of the rule above described. On the opposite side of the center line is shown the half section, showing the joints. Thus the top of the basin has a flange and wire edge at *f*, while the lower part has a flange, *h*, joining inside of the flange *j* of the bottom *i*. The radius for the bottom is shown by D F.

PATTERNS FOR A CHILD'S BATHTUB

In an accompanying illustration, Fig. 114, is shown a perspective view of a child's bathtub, made in two pieces, with seams at A and B on both sides. The top edge is wired, as shown at A in Fig. 115, and edged or double seamed, as shown at D. Draw the elevation of the tub, as shown by A B C D, and in its proper position below this draw the plan, as shown by E F, the semicircular ends being struck from the centers *a* and *a*. From *a* erect the vertical line *a* H, which intersect at H by the line B C, extended. Then H is the center with which to describe the pattern.

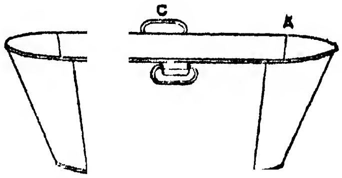


Fig. 114. Perspective View of Tub

Using H as center, and radii equal to H C and H B, draw the arcs *b b*′ and 1 9, as shown. From 1, on the outer arc, draw a radial line to the center H, intersecting the inner arc at *b*. Now divide the semicircle 1 9 in plan into equal parts, as shown, and place this

stretchout on the outer arc in the pattern, as shown from 1 to 9. From 9 draw a radial line to the center H, cutting the inner arc at b'. At right angles to 9 b', draw 9 10 and b' t, equal to 9 10 in plan. Then 1 10 t b is the pattern for 1 10 10′ 1′ in plan, with seams at 1 and 10. These seams are made by turning the ordinary lock edge, of the required size, and grooving, either with a hand tool or the many machines on the market.

Laps should be allowed to the pattern for seaming and wiring. The handle at C in Fig. 114 is made from rods of suitable size, with a tin clip clinched around it and is riveted, as shown. The inner plan in Fig. 115 is the pattern for the bottom of the tub, and to this edges must be added for seaming.

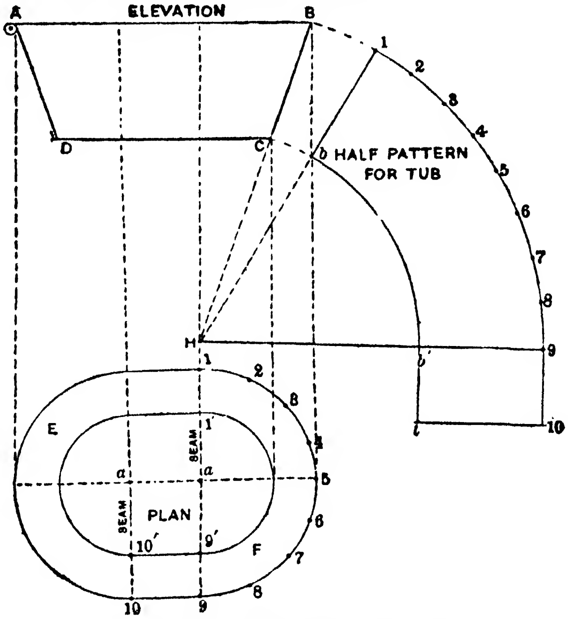


Fig. 115. Patterns for the Tub

PATTERN FOR SINK DRAINER

It is often the case that the trap under the kitchen sink is choked or blocked, owing to a collection of refuse matter. To avoid this a sink drainer is used. A perspective view of an article of this kind is shown in Fig. 116. This drainer is intended for use in the kitchen sink, being fastened through the wire loops A, B and C. The refuse matter is poured into the drainer, from which it is easily removed. It can be made of tin or black or galvanized iron, but where a good job is wanted it had best be made of 16-ounce copper.

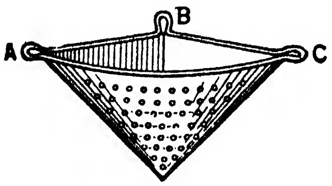


Fig. 116 Finished View of Sink Drainer

To obtain the pattern for any sized drainer proceed as follows: First draw the plan of the drainer, A B C in Fig. 117, which gives the size of the top opening. A B C is a right angle, the arc A C being struck from the center B. Directly above the plan draw the side elevation, as shown by D E F, making D E the

desired hight and E F equal to A B. Draw a line from F to D, which will give the flare of the drainer and radius with which to strike the pattern. Divide the arc A C in the plan into an equal number of parts, as shown from 1 to 6. Then, using D F in the elevation as radius, and D in Fig. 118 as the center, describe the arc 1 6. From any point in the arc, as 1, draw the line 1 D. Then, starting from the point 1, lay off on the arc 1 6 the stretchout of the arc 1 6 in the plan, Fig. 117, as shown by similar figures on 1 6 in Fig. 118. Draw a line from 6 to D. Then will 1 6 D represent

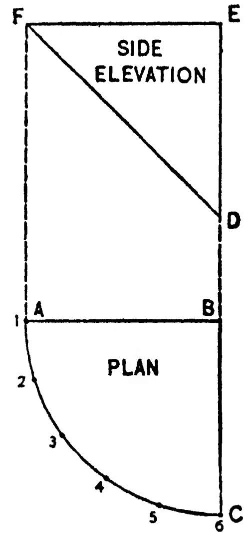


Fig. 117. Plan and Elevation

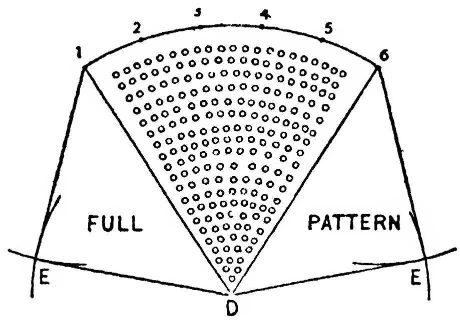


Fig. 118. The Pattern Shape

the front of the drainer shown in Fig. 116. Small perforations should be punched as shown in Fig. 118. With D E in Fig. 117 as radius, and D in Fig. 118 as center, describe the arcs E and E, which intersect with arcs struck from 1 and 6 as centers, and F E or A B in Fig. 117 as radius. Draw lines, as in Fig. 118, from 1 to E to D and D to E to 6. Then will 1 6 E D E 1 be the full pattern. Laps must be allowed for seaming at the corner B in the plan in Fig. 117, and edges for wiring at the top, allowing wire loops to project at the corners, A, B and C in Fig. 116.

PATTERN FOR OVAL PUDDING PAN

In making oval pudding pans of IX or IC tin, care must be taken to obtain a true pattern, so that when the pattern is formed up to the required shape it will be true to its profile and have a level line on top and bottom. However, before a pattern can be obtained, it must first be known how to construct the elliptical figure, so that a set of centers can be obtained with which to strike the arcs desired.

In Fig. 119 is shown the method of drawing an approximate ellipse to given dimensions. Let A B represent the length of the pudding pan, and C D its width. Take the distance of C D and place it from B on B A, as shown by the dot E.

Divide the distance E to A into three equal parts, as shown by 1 and 2. Take two of these parts as radius, or E 2, and with O as center, describe arcs intersecting the line B A at X and X^1. Then with X X^1 as radius, and using X and X^1 as centers, describe arcs intersecting each other at C and D. Draw lines from C to X and C to X′, extending them toward F and G, respectively. In similar manner, from D draw lines to X and X′, extending them toward I and H, respectively. With X and X^1 as centers and X A or X^1 B as radii, describe arcs intersecting the lines I D, F C, and G C, H D at J, K and L, M, respectively. In similar manner, with D and C as centers and D C and C D as radii, describe arcs which must meet the previous arcs at J M and L K, respectively, forming an approximate ellipse.

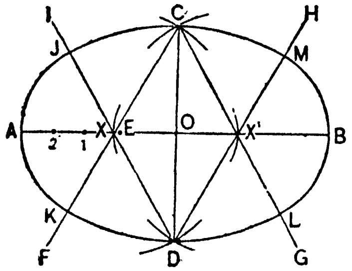


Fig. 119. Method of Drawing an Approximate Ellipse

In Fig. 120, let A B C D represent the side elevation of the pan, with a vertical hight equal to R C. In precisely the same manner as described in Fig. 119 draw the plan, as shown, in correct relation to the elevation, letting E F G H be the plan of the top of the pan, and J K L I the plan of the bottom, struck from the centers O, M, P and N.

To obtain the radii with which to strike the pattern proceed as follows: Draw any horizontal line, R E in Fig. 121, equal to N E in plan in Fig. 120. Take the vertical hight R C in elevation and place it, as shown by R C in Fig. 121, on a line drawn at right angles to E R. Parallel to R E and from the point C, draw the line C J, equal to N J in plan in Fig. 120. Draw a line from E to J in Fig. 121, extending it until it meets the line R O at O. Then will O J and O E be the radii with which to strike the pattern for that part of the pan shown in plan in Fig. 120 by E F K J and G H I L.

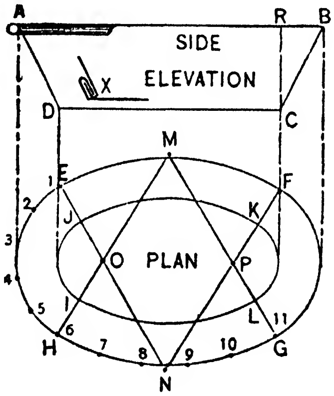


Fig. 120. Plan and Elevation of Pudding Pan

Take the distance from P to F in plan, and place it, as shown from R to F in Fig. 121 on the line R E. In similar manner take the distance from P to K in plan in Fig. 120 and place it in Fig. 121 on the line C J, as shown from C to K. Draw a line from F to K, extending it until it meets the center line R O at P. Then will P K and P F be the radii with which to strike the pattern for that part of the plan shown in plan in Fig. 120 by K F G L and I H E J.

Next divide the curve from E H in plan into equal spaces, as shown by the small figures 1 to 6; also divide the curve H to G in equal spaces, as shown from 6 to 11.

For the pattern proceed as follows: In Fig. 122 draw any vertical line, as E O, and with radii equal to O J and O E in Fig. 121, and using O in Fig. 122 as center, describe the arcs J K and E F, as shown. Set the dividers equal to the spaces in H G in plan in Fig. 120, and starting from E in Fig. 122, step off the required number of spaces, as shown from 11 to 6.

From 6 draw a line to O, intersecting the curve J K at K. With P F in Fig. 121 as radius and F in Fig 122 as center, describe an arc intersecting the line F O at P. Then, using P as center and with radii equal to P K and P F, describe the arcs K L and F G, respectively, as shown. On the arc F G, starting from F or point 6, lay off the stretchout of H E in plan in Fig. 120, as shown by points 6 to 1 on the curve F G in Fig. 122. From 1 draw a line to P, intersecting the arc K L at L. Then will E F G L K J be the half pattern. If the pan is to be made in one piece, duplicate this half pattern opposite the line E J.

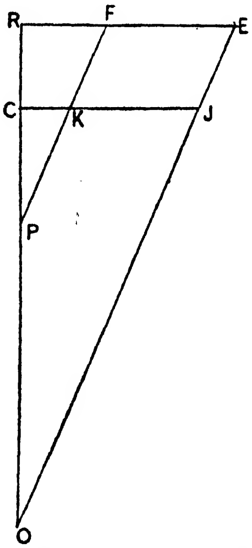


Fig. 121.—Obtaining Diagram of Triangles

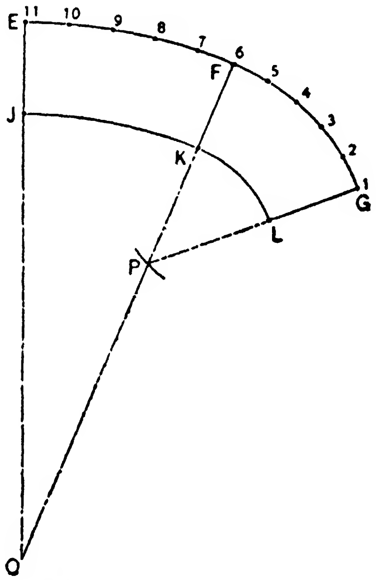


Fig. 122.—One-half Pattern Shape

Should the pan be desired in four sections, two pieces of the patterns, E F K J and F K L G, would be required. Allowance should be made for seaming and wiring. The bottom of the pan is shown by J K L I in plan in Fig. 120, which is double seamed to the body, similiar to X in the elevation.

PATTERNS FOR A BATHTUB

The following is an exemplification of the methods of obtaining the patterns of a sheet metal bathtub, in which Fig. 123 shows the finished view of the tub, which should be wired at B and double seamed to the bottom at C. In Fig. 124, D E 7 H C 12 is the plan of the bottom, and A F 8 G B the plan of the top, shown respectively by J K and I L in elevation. It will be noticed that the foot of the bath in plan has equal flare, as shown by A B C D, while the head has unequal flare, as shown by E F G H. The arcs are struck from the centers *a*, *b* and *c*, respectively.

From *a* draw the vertical line *a d*, which intersect at *d* by I J extended. Divide the quadrant C 12 into equal spaces, as shown by 9, 10, 11 and 12. From these points drop vertical lines, not here shown, intersecting J K in elevation at 9′ to 12′. From *d*, through these points, draw lines cutting I L, as shown. From these points draw horizontal lines, intersecting J I extended at 9″ to 12″. Using *d* as center, with *d* J as radius, draw the arc L M, upon which place the stretchout of 9 12, as shown. Through these points draw radial lines, which intersect by arcs, struck from *d* as center, with radii equal to *d* 9″, *d* 10″, *d* 11″, and *d* 12″. Then will L M N O be the pattern for the foot of the bath.

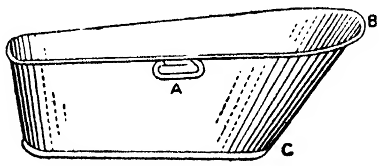


Fig. 123. The Bathtub

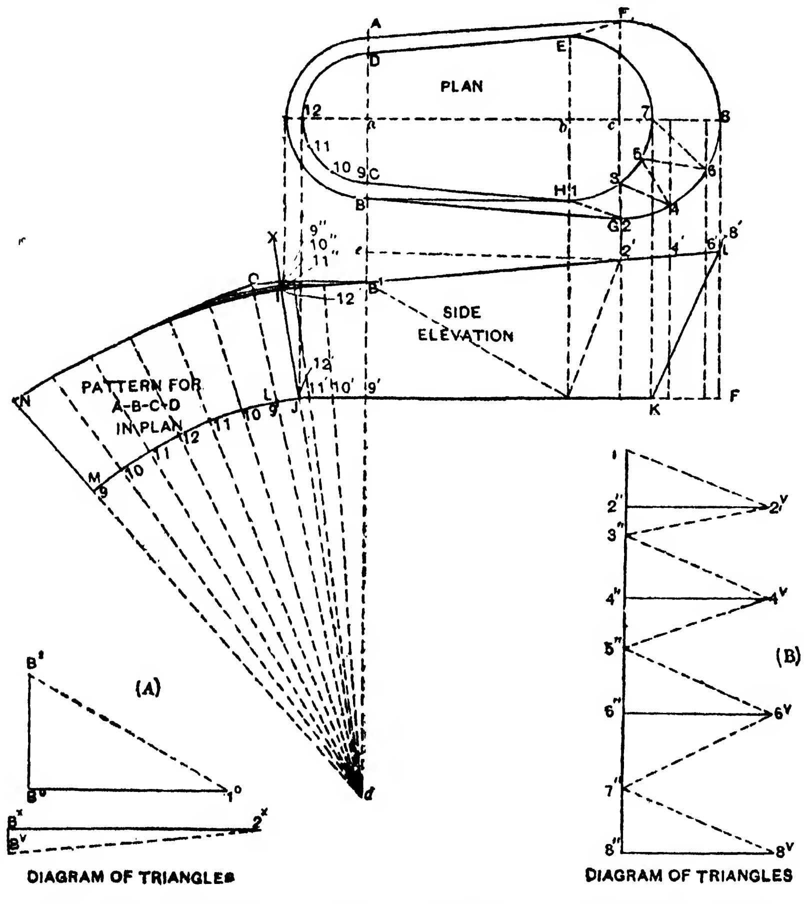


Fig. 124. Plan and Elevation, Diagram of Triangles and Pattern of Foot End

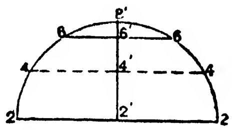


Fig. 125. Developed Section on 2′ 8′

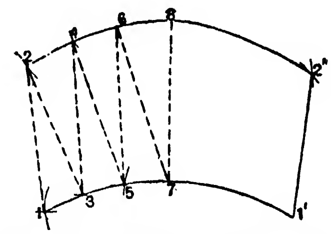


Fig. 126. Pattern for Head End

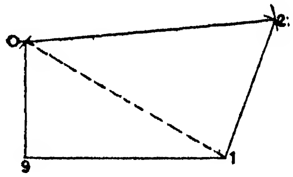


Fig. 127. Pattern for Side

The head of the tub is developed by triangulation. To do this, divide the half plans 7 H and 8 G both into equal parts, as shown from 1 to 7 and 2 to 8,

and draw dotted lines, as shown. From 2 to 8 drop vertical lines in the elevation, cutting I L and J K extended.

Take the various lengths in plan, as 1 2, 2 3, 3 4, etc., and place them on the vertical line 1″ 8″ in diagram B, as shown by similar numbers. At right angles to 1″ 8″, draw the lines 2″ 2^v, 4″ 4^v, 6″ 6^v and 8″ 8^v, equal in hight to 2′, 4′, 6′ and 8′ in elevation, measuring from the line J F. Connect the various points in diagram B, which represent the true lengths on similar numbered lines in plan.

As the top of the tub is not on a horizontal plane, a true section must be obtained on 2′ 8′ in elevation. Take the various distances 2′ to 8′, and place them on the vertical line in Fig. 125, through which draw horizontal lines. Measuring from the center line in plan in Fig. 124, take the various distances to points 2, 4 and 6, and place them on similar lines in Fig. 125 on either side of 2′ 8′. Then 2 8′ 2 is the developed section on 2′ 8′ in elevation.

Fig. 126 shows the pattern for the head. The distances on 1 1′ are obtained from 1 7 in plan in Fig. 124. The distances along 2 2′ in Fig. 126 are obtained from Fig. 125. The lengths of the lines in Fig. 126 are obtained from the triangles in diagram B in Fig. 124.

The pattern for the side C B G H in plan is also obtained by triangulation. C H shows its true length. To obtain the true length of H B and B G, proceed as follows: Take the distance 1 B and place it as shown by 1° B° in diagram A. Erect B° B^2, equal to 9′ B^1 in elevation, and draw a line from B^2 to 1° in A. In similar manner, take the distance from B to 2 in plan and place it in diagram A, as shown from B^x to 2^x. Draw B^x B^v, equal to *e* B^1 in elevation, and draw a line from B^v to 2^x.

To develop the pattern, take the distance from 9 to 1 in plan and place it as shown from 9 to 1 in Fig. 127. With 9 as center, and 9 O in the pattern in Fig. 124 as radius, describe the arc O in Fig. 127, which intersect by an arc struck from 1 as center and 1° B^2 in diagram A in Fig. 124 as radius. Then, with B^v 2^x as radius and O as center, in Fig. 127, describe an arc, which intersect by an arc struck from 1 as center and 1 2 in Fig. 126 as radius. Connect the points in Fig. 127, which is the pattern for the sides of the tub. Edges must be allowed for wiring and seaming.

PATTERNS FOR MILK BUCKET

To lay out a pattern for the milk bucket shown in Fig. 128, first draw the side elevation of the bucket, A B C D E F G, as at Fig. 129; also the plan view on

F E, as shown by K L M N, struck from the center I, through which erect the center line J C. Draw in its proper position to A G the true section on that line, O P R S. In line with the side elevation, draw the rear elevation of the bucket, T U V W X, the arc T U V being struck from the center *a*, and the distances Y W, Y X and 1″ V and 1″ T being equal, respectively, to H E and C D in the side elevation. The opening Z A^1 & G^1 represents the vertical section on A G in side elevation. Through the rear elevation draw the center line Y U, and divide the half curve U T into equal spaces, as shown by 1′, 2′, 3′ and 4′, through which draw lines intersecting the center line U Y at 3″, 2″ and 1″, and the curved line B C in side elevation (on which T U V in rear is a vertical section) at 1‴, 2‴, 3‴ and 4‴.

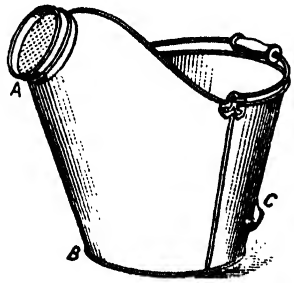


Fig. 128. Perspective View of Milk Bucket

It now becomes necessary to obtain a developed section on the curved line B C, for which proceed as follows: Extend the line Y U in rear elevation, as shown by U A^1, upon which place the stretchout of the curved line B C, as shown by 1⁗ to 4⁗ on A^1 U, through which draw horizontal lines, as shown, which intersect by lines drawn from similar numbered intersections in T U at right angles to T V. Trace a line through points thus obtained; then will 4⁗ 1° 1⁗ be the half developed section, which can be traced opposite the center line to complete the full section.

As a bucket of this kind is usually made in two pieces, with a seam at the sides, as shown in Fig. 128, first develop the rear of the bucket, as shown in Fig. 129. Extend the line D E in side elevation until it intersects the center line at J; then, using J as center and radii equal to J E and J D, draw the arcs E E^2 and D D^2. At any point, as D^1, on the arc D D^2, draw a line to the apex J, intersecting the inner arc at E^1. Divide the half plan K L M into equal parts, as shown from 1 to 7. Set the dividers equal to one of these spaces, and, starting from E^1, step off six parts, as shown from 1 to 7. Through 7 draw a line to J, extending it until it intersects the outer arc at D^2. Then will D^1 D^2 E^2 E^1 be the pattern for C D E H in side elevation.

The pattern for the part shown by A B C H F G will be developed by triangulation. To avoid a confusion of lines, the diagram shown in Fig. 130 is a reproduction of part of Fig. 129. Transfer the points 2‴ and 3‴ on Fig. 129 to Fig. 130, as 6′ and 7′. Take tracings of the half sections H E D C and S O P,

also the quarter plan N I M, and place them on similar lines in Fig. 130, on which they represent sections, as shown respectively by H 9′ 8′ C, G 3 A and F H 9. Divide the section F 9 into three equal parts, and as B C contains three spaces, divide the section G 3 A into six parts. Number these intersections, as shown. At right angles to G A and H F, and from the various intersections on G 3 A and 9 F, draw lines intersecting their base lines, as shown. Connect

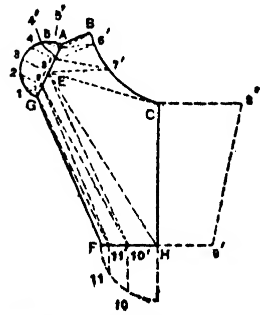
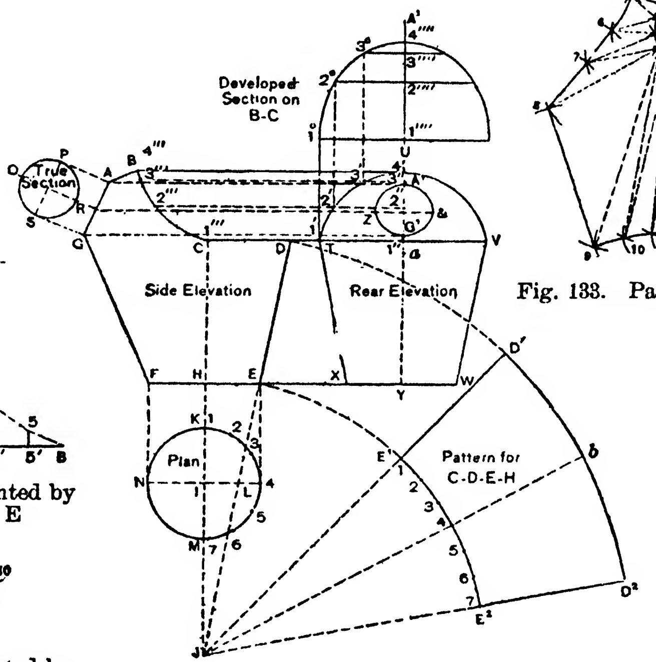


Fig. 130. Obtaining Measurements for Sections



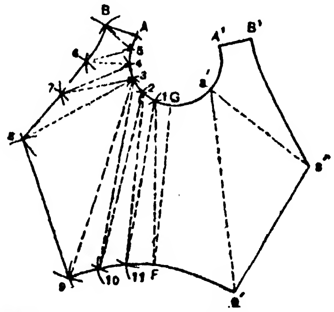


Fig. 133. Pattern for the Front

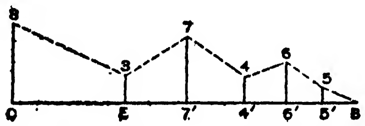


Fig. 131. Sections Represented by Dotted Lines on A B C E

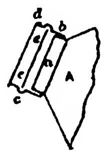


Fig. 134. The Strainer

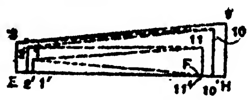


Fig. 132. Sections Represented by Dotted Lines on E H F G

Fig. 129. Plan, Elevations, True Section and Pattern

opposite points, as B to 5′ to 6′ to 4′ to 7′, etc., as shown. Then will these lines represent the bases of sections which will be constructed, the altitudes of which are equal to the various hights in the sections. For example, take the distances of C E and E 7′ and place them, as shown, on the horizontal line C B in Fig. 131 by C E and E 7′, from which points, at right angles to the horizontal line, erect the lines C 8 and E 3 equal to C 8′ and E 3 in Fig. 130, and erect 7′ 7 in Fig. 131 equal in hight to 2′′′′ 2° in the developed section in Fig. 129. Then draw lines from 8 to 3 to 7 in Fig. 131, which represent the true lengths on similar numbered lines in Fig. 130. Proceed in this manner for the balance, as shown in Fig. 131, which represent the true lengths of the dotted lines shown in A B C E in Fig. 130. The true lengths of the dotted lines in E H F G are determined by the same method, the diagram of sections being shown in Fig. 132. In this the lines are drawn inside of one another to save space.

For the pattern proceed as is shown in Fig. 133. Draw G F equal in length to G F in Fig. 130. Using G 1 as radius and G in Fig. 133 as center, describe the arc 1, which intersect by an arc struck from F as center and F 1 in Fig. 132 as radius. Using as radius F 11 in Fig. 130, and F in Fig. 133 as center, describe the arc 11, which intersect by an arc struck from 1 as center and 1 11 in Fig. 132 as radius. Proceed in this manner, using alternately as radii, first the divisions in G 3 E in Fig. 130, then the length of the slant lines in Fig. 132, the divisions in F 8 in Fig. 130, and again the proper slant line in Fig. 132, until the line 3 9 in Fig. 133 is obtained. Using 9 as center and 9′ 8′ in Fig. 130 as radius, describe the arc 8 in Fig. 133, which intersect by an arc struck from 3 as center and 3 8 in Fig. 131 as radius. Then, starting from the point 8 in Fig. 133, proceed in similar manner as before, using alternately as radii first the division in the developed section starting at 1° in Fig. 129, then the length of the slant lines in Fig. 131, the divisions in E 3 A in Fig. 130, then again the length of the proper line in Fig. 131, until the line B A in Fig. 133 has been obtained, which is equal to B A in Fig. 130. Then will A B 8 9 F G A in Fig. 133 be the half pattern. Trace this half opposite the line G F, as shown, forming the pattern for the front of the bucket. Edges should be allowed for wiring and seaming.

The pattern for the bottom is shown by K L M N in plan in Fig. 129, to which edges must be allowed for double seaming to the body at B in Fig. 128. Cut out a lift, such as is shown at C in Fig. 128, to be soldered to the bucket where shown. Fig. 134 shows the construction of the strainer at A in Fig. 128. Although made in various ways, this is perhaps the simplest. A in Fig. 134 represents the mouth of the bucket, on which the collar *a*, 1 inch wide, is soldered. Roll up another collar about 2 inches wide, with a hem edge at *d* and a swedge turned outward, as at *c*. Make this collar of such size that it will make a tight joint over the collar *a* at *b*, but so it also can be taken off for cleaning. Cut a disk of wire cloth of the required diameter, as *e e*, which fit into the swedge *c* and solder. Putting on the handle completes the bucket.

PATTERNS FOR A TWO-PIECED COAL HOD

A finished view of a two-pieced coal hod, with seams at the sides, is shown in Fig. 135. To make this article proceed as follows: First draw, as in Fig. 136, the center line 9 A, and with any point, as L, for center, describe the circle 1 *a* *d* 4, representing the bottom of the hod. Through L, at right angles to 9 A,

also the quarter plan N I M, and place them on similar lines in Fig. 130, which they represent sections, as shown respectively by H 9′ 8′ C, G 3 A ai H 9. Divide the section F 9 into three equal parts, and as B C contains t spaces, divide the section G 3 A into six parts. Number these intersections shown. At right angles to G A and H F, and from the various intersections G 3 A and 9 F, draw lines intersecting their base lines, as shown. Con

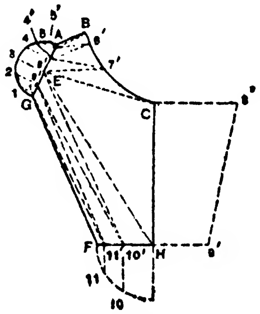
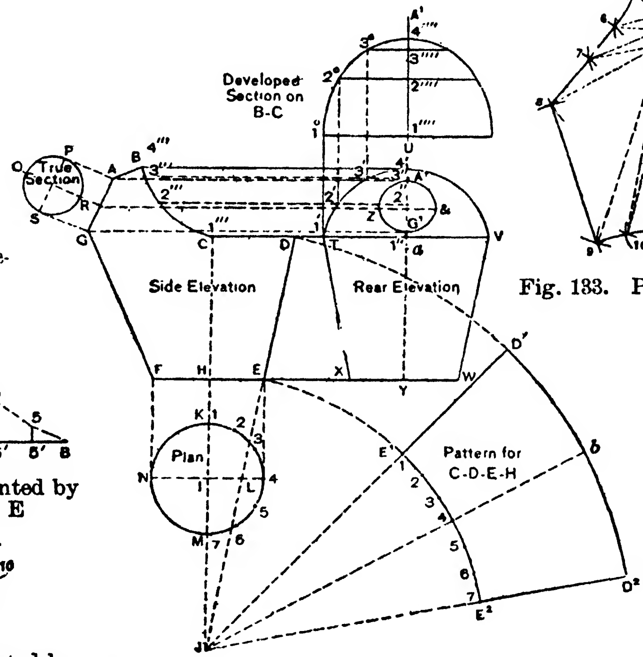


Fig. 130. Obtaining Measurements for Sections



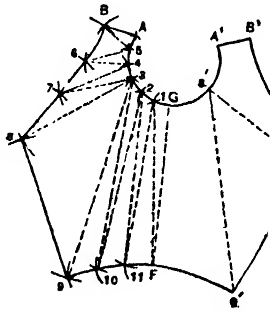


Fig. 133. Pattern for the

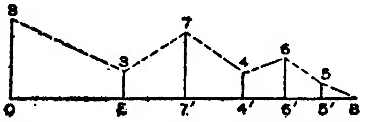


Fig. 131. Sections Represented by Dotted Lines on A B C E

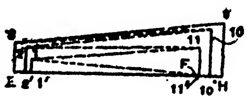


Fig. 132. Sections Represented by Dotted Lines on E H F G

Fig. 129. Plan, Elevations, True Section and Pattern

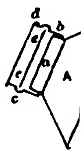


Fig. 134. Strainer

opposite points, as B to 5′ to 6′ to 4′ to 7′, etc., as shown. Then will t lines represent the bases of sections which will be constructed, the altitud which are equal to the various hights in the sections. For example, take the tances of C E and E 7′ and place them, as shown, on the horizontal line C Fig. 131 by C E and E 7′, from which points, at right angles to the horiz line, erect the lines C 8 and E 3 equal to C 8′ and E 3 in Fig. 130, and 7′ 7 in Fig. 131 equal in hight to 2′′′′ 2° in the developed section in Fig. Then draw lines from 8 to 3 to 7 in Fig. 131, which represent the true le on similar numbered lines in Fig. 130. Proceed in this manner for the balan shown in Fig. 131, which represent the true lengths of the dotted lines show A B C E in Fig. 130. The true lengths of the dotted lines in E H F (determined by the same method, the diagram of sections being shown in Fig. In this the lines are drawn inside of one another to save space.

For the pattern proceed as is shown in Fig. 133. Draw G F equal in length to G F in Fig. 130. Using G 1 as radius and G in Fig. 133 as center, describe the arc 1, which intersect by an arc struck from F as center and F 1 in Fig. 132 as radius. Using as radius F 11 in Fig. 130, and F in Fig. 133 as center, describe the arc 11, which intersect by an arc struck from 1 as center and 1 11 in Fig. 132 as radius. Proceed in this manner, using alternately as radii, first the divisions in G 3 E in Fig. 130, then the length of the slant lines in Fig. 132, the divisions in F 8 in Fig. 130, and again the proper slant line in Fig. 132, until the line 3 9 in Fig. 133 is obtained. Using 9 as center and 9′ 8′ in Fig. 130 as radius, describe the arc 8 in Fig. 133, which intersect by an arc struck from 3 as center and 3 8 in Fig. 131 as radius. Then, starting from the point 8 in Fig. 133, proceed in similar manner as before, using alternately as radii first the division in the developed section starting at 1° in Fig. 129, then the length of the slant lines in Fig. 131, the divisions in E 3 A in Fig. 130, then again the length of the proper line in Fig. 131, until the line B A in Fig. 133 has been obtained, which is equal to B A in Fig. 130. Then will A B 8 9 F G A in Fig. 133 be the half pattern. Trace this half opposite the line G F, as shown, forming the pattern for the front of the bucket. Edges should be allowed for wiring and seaming.

The pattern for the bottom is shown by K L M N in plan in Fig. 129, to which edges must be allowed for double seaming to the body at B in Fig. 128. Cut out a lift, such as is shown at C in Fig. 128, to be soldered to the bucket where shown. Fig. 134 shows the construction of the strainer at A in Fig. 128. Although made in various ways, this is perhaps the simplest. A in Fig. 134 represents the mouth of the bucket, on which the collar *a*, 1 inch wide, is soldered. Roll up another collar about 2 inches wide, with a hem edge at *d* and a swedge turned outward, as at *c*. Make this collar of such size that it will make a tight joint over the collar *a* at *b*, but so it also can be taken off for cleaning. Cut a disk of wire cloth of the required diameter, as *e e*, which fit into the swedge *c* and solder. Putting on the handle completes the bucket.

PATTERNS FOR A TWO-PIECED COAL HOD

A finished view of a two-pieced coal hod, with seams at the sides, is shown in Fig. 135. To make this article proceed as follows: First draw, as in Fig. 136, the center line 9 A, and with any point, as L, for center, describe the circle 1 *a* *d* 4, representing the bottom of the hod. Through L, at right angles to 9 A,

draw the line B 12. Establish the projection of the back flare of the hod in p as shown by d 12, and with L as center and L 12 as radius, describe the se

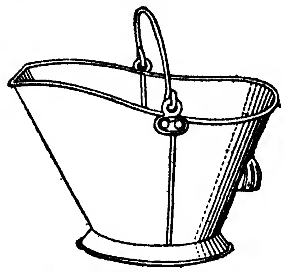


Fig. 185. View of Completed Hod

circle, intersecting the center line at 5 and 9. Tl at pleasure, draw the plan view of the front and sid the coal hod, as shown by 5 8 8^v 9. Directly below plan draw the elevation of the hod, as shown by 8 $12'$ d' $1'$, projecting all points from the plan, as show the dotted lines. The curve $8'$ $5'$ in the elevation at top of the hod can be drawn at pleasure. Draw the el tion for the foot, or base, as shown by $1'$ j i d', wl completes the plan and elevation of the coal hod, this of course, being esse for the developing of the patterns.

The patterns will be developed so that the seams will be at the sides, as sh in plan and elevation. For the pattern for the back of the hod, which will developed by the radial line, proceed as follows: Extend the line $12'$ d' in el tion until it intersects the center line 9 A at A. Then, using A as center radii equal to A d' and A $12'$, describe the arcs $12'$ 5 and d' d'''. From point, as $9'$ on the arc $12'$ 5, draw the radial line to A, intersecting the arc d' at d''. Divide the semicircle 9 12 5 in plan into an equal number of parts shown by the small figures, and, starting from $9'$ on the arc $12'$ 5, step off stretchout of 9 12 5 in plan, as shown by similar figures on the arc $9'$ 5. Fr 5 draw a radial line to A, intersecting the inner arc at d'''. Then will $9'$ 5 d'' be the pattern for the back of the hod.

For the pattern for the foot, or base, extend the lines i d' and j $1'$ until t intersect at l. Using l as center, with radii equal to l d' and l i, and l' in N center, describe the arcs i' i'' and $4''$ a'. From any point, as i'', draw the ra line to l', intersecting the inner arc at a'. Divide one-half of the small circle plan into an equal number of spaces, as shown by a to f to 4, and, starting fr a' in N, step off on a' $4''$ the stretchout of one-half of the small circle in plan shown by similar letters in N. From l' draw a line through $4''$, intersecting outer arc at i'. Then will i' i'' a' $4''$ be the half pattern for the foot.

The pattern for the front and sides, 5 8 8^v 9 in plan, will be developed triangulation. As both sides of the hod are symmetrical, the pattern for one s only will be struck, from which the opposite side can be traced. In plan div the space 8 to 5 into an equal number of parts, as shown by the figures 5, 6 and 8. In the same manner divide the quarter circle 1 to 4 into the same nu ber of equal parts, as shown by the small figures 1, 2, 3 and 4. Draw solid li

from 1 to 8, 2 to 7, 3 to 6 and 4 to 5, and dotted lines from 1 to 7, 2 to 6 and 3 to 5. From the intersections 1, 2, 3 and 4 project vertical lines, not shown, to similar part in elevation, locating the points 1′, 2′, 3′ and 4′. In a similar manner, from points 5, 6, 7 and 8 drop vertical lines, as shown, intersecting the curved line at the top of the hod in elevation at 5′, 6′, 7′ and 8′. If desired, the points can be connected in elevation by means of solid and dotted lines, as shown, although this is not necessary.

Then will the solid and dotted lines in the plan represent the bases of triangles which will be constructed, vertical hights of which are equal to points having

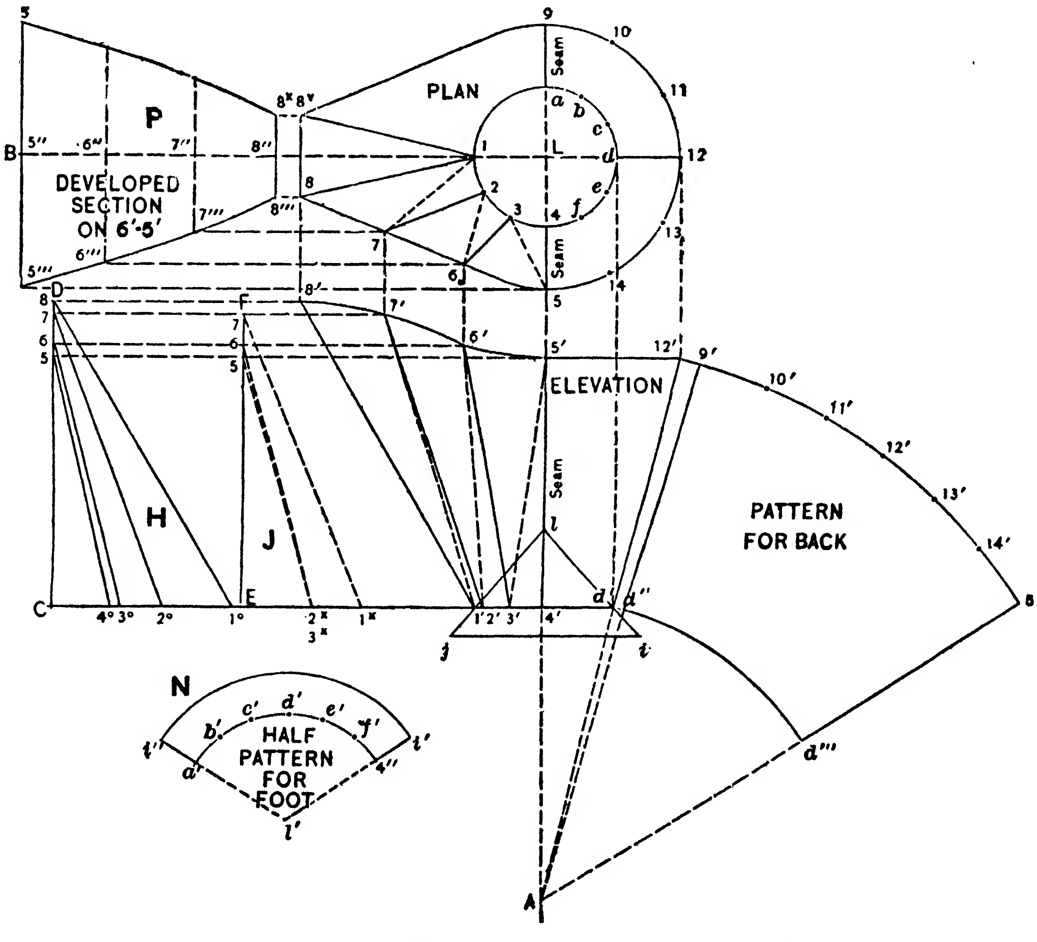


Fig. 186. Plan, Elevation, Developed Section, Diagram

similar numbers in elevation. For the triangles on solid lines proceed as is shown in H. Extend the line d' 1′ in elevation, as shown by d C. From C erect the perpendicular line C D. Then, from the points 5′, 6′, 7′ and 8′ in elevation, draw horizontal lines intersecting the vertical line D C at 5, 6, 7 and 8. Take

the various distances in plan, 8 to 1, 7 to 2, 6 to 3 and 5 to 4, and place them in H on the line C d', measuring in each instance, as shown, from C to 1°, 2°, 3° and 4°, and draw lines from 1° to 8, 2° to 7, 3° to 6 and 4° to 5, which will represent the true lengths on similar numbered lines in plan.

In a similar manner obtain the triangles on the dotted lines in plan. From any point, as E in J, erect the vertical line E F, intersecting the horizontal lines previously drawn from 5' to 7' at 5, 6 and 7. Take the various distances of the dotted lines in plan, 7 to 1, 6 to 2 and 5 to 3, and place them in J, as shown, from E to 1^x, E to 2^x and E to 3^x. Draw dotted lines from 7 to 1^x, 6 to 2^x and 5 to 3^x, which represent the true lengths on similar numbered lines in plan.

It is now necessary to obtain a developed section on the curve 5' 8' in elevation, so that the true lengths on this curb can be obtained. On the center line B 12 in plan, lay off the stretchout of the curve 5' to 8', as shown by similar figures 5'' to 8'' on B 12. At right angles to B 12 and through these points draw lines, as shown, which intersect by horizontal lines drawn from similar numbered points on 5 8 in plan, resulting in the intersections 5''' to 8'''. Through these points trace a line, as shown. In this case the opposite side has been traced, which is not necessary in practice. Then will 5^x 5''' 8''' 8^x be the developed section or the cover to close the opening on 5' 8' in elevation, if it may be stated in that way.

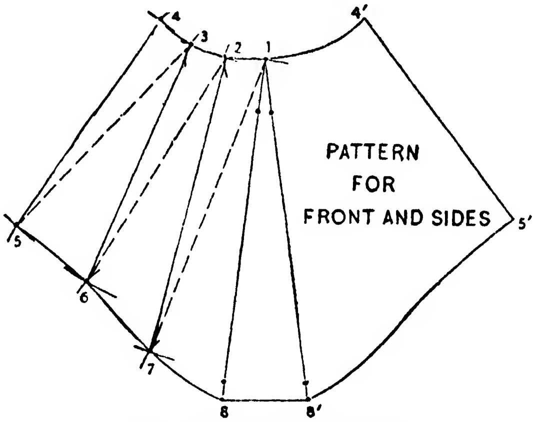


Fig. 137. Coal Hod Pattern

Having all the necessary measurements with which to develop the pattern, draw any horizontal line, as 8 8' in Fig. 137, equal to 8 8^v in plan in Fig. 136. With radii equal to 8 1° in H and 8 and 8', Fig. 137, as centers, describe arcs intersecting each other at 1. With 8''' 7''' in P, Fig. 136, as radius and 8 in Fig. 137 as center, describe the arc 7, which intersect by an arc struck from 1 as center and 1^x 7 in J, Fig. 136, as radius. Then with 1 2 in plan as radius and 1 in Fig. 137 as center, describe the arc 2, which intersect by an arc struck from 7 as center and 7 2° in H, Fig. 136, as radius. Proceed in this manner, using alternately, first the divisions on 8''' 5''' in P, and then the lengths of the slant lines in J, the divisions on 1 4 in plan and then the lengths of the slant lines in H, until the line 4 5 in Fig. 137 is obtained, which should be equal in length to 5 d''' in

the pattern for the back shown in Fig. 136. Draw a line through the points thus obtained in Fig. 137, as shown by 1 4 5 8. Trace this opposite the line 1 8′, as shown by 1 4′ 5′ 8′. Then will 4 1 4′ 5′ 8′ 8 5 be the pattern for the front and sides of the coal hod.

To all patterns laps must be allowed for wiring and seaming.

PATTERNS FOR OBLONG WASH BOILER WITH ROUNDED CORNERS

In Fig. 138 is shown a perspective view of an oblong wash boiler with rounded corners. How to develop the cover for this one piece with a seam along A will be shown. First draw the plan of the boiler, as shown by E G F H in Fig. 139, the rounded corners being struck from the centers *a a a a*. As the four quarters of the cover are alike, it will only be necessary to obtain the pattern for one quarter and there join the various parts together, as shown in the pattern Y.

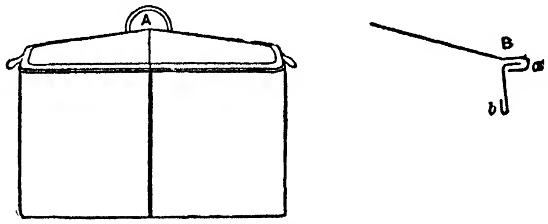


Fig. 138. Perspective View of Article

Bisect the side G in plan and obtain the point 1; also bisect the end F in plan and obtain the point 6. Now divide the quarter circle 2 5 in plan into any desired number of parts, as shown by 3 and 4. From the numbers 1 to 6 draw lines to the center J. Take the various distances J 1, J 2, J 3, J 4, J 5 and J 6, and place them on the line D C in

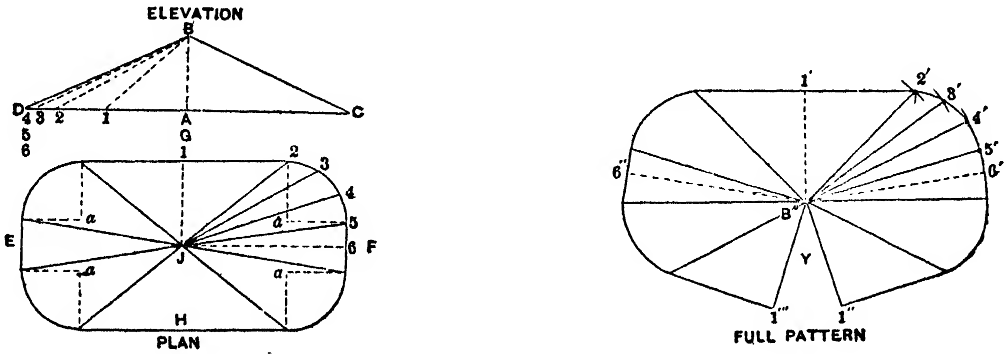


Fig. 139. Developing the Patterns

elevation, measuring from the point A, and obtain the points 1 2 3 4 5 6, from which draw lines to the apex B. These lines represent the true lengths with which to describe the pattern.

Draw any vertical line in Y, as B° 1′, equal to B 1 in elevation. With radius equal to B 2, and B° in Y as center, draw the arc 2′, which intersect by an arc struck from 1′ as center and 1 2 in plan as radius. With radii equal to B 3, 4 5 6 in elevation, and B° in Y as center, draw the arcs as shown.

Set the dividers equal to the various spaces between 2 and 6 in plan, and starting from 2′ in the pattern Y, step to arc 3′, 4′, 5′ and 6′ and draw a line from 6′ to B° and trace a line from 2′ to 6′. B°, 1′, 6′, B°, is then the quarter pattern, shown in plan by G J F. Join the four quarter patterns in Y, as shown by 1′, 6″, B°, 6″, B°, 1‴ and B°, 1″, 6′, which completes the full pattern. Laps and edges should be allowed for seaming to the rim, as shown in B in Fig. 138 by *a* and *b*.

PATTERN FOR WASH BOILER COVERS

A wash boiler with a flat bottom, such as is shown in Fig. 140, is an article often made of IX tin with copper bottom, and sometimes entirely of 16 or 18-ounce cold rolled copper. Knowing the size of the boiler, a plan of the same is drawn, as shown in Fig. 141, in which A C is the length and B D the width, the semicircular ends being struck from the centers *a* and *b*. Edges allowed to this plan, for double seaming, will give the pattern for the bottom. The pattern for the body is usually made of such hight as to avoid any waste in the metal, after the edges and wire have been allowed for, the length being obtained by taking a stretchout around the plan.

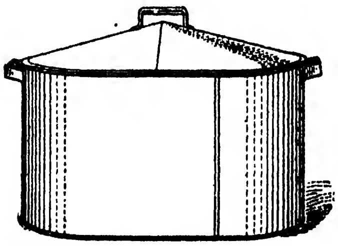


Fig. 140. Perspective View of Finished Boiler

The part to which special attention must here be given is the pitched cover, which is developed on the principles of developing a scalene cone. As both halves of the cover are symmetrical, only one-half of the pattern will be developed. Through the center *a* in plan, at right angles to *a b*, draw the diameter 1 1, as shown. Directly above the plan draw an elevation of the cover, giving the required rise J F, as shown, and draw the lines F E and F G. Divide the semicircle 1 A 1 in plan into an equal number of parts, as shown by the small figures 1 to 3 to 1, and from these points draw lines to the apex F^1.

F E in elevation represents the true length on the line F^1 A in plan, and before the pattern can be obtained, a diagram of triangles must be constructed, giving the true lengths on each of the other radial lines in plan, which are obtained as

follows: With F^1 as center and with radii equal to F^1 1, F^1 2 and F^1 D, draw arcs intersecting the center line A b in plan at 2′, 1′ and D^1 respectively. From these points, at right angles to A b, draw lines intersecting the base line E G in elevation at 3″, 2″, 1″ and D^2, from which points draw lines

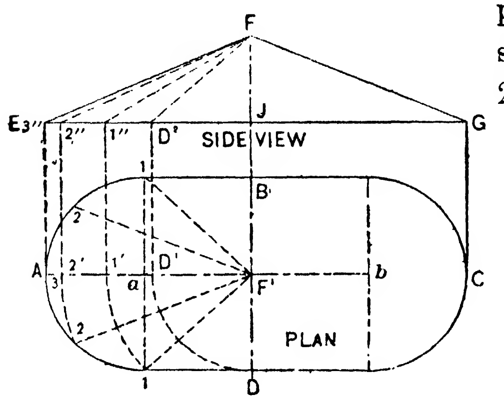


Fig. 141. Plan, Side View of Cover and Diagram of Triangles

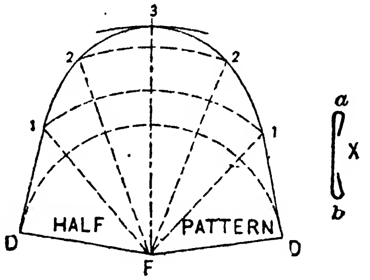


Fig. 142. Half Pattern of Cover

to the apex F. Then will these lines represent the true distances on similarly numbered lines in plan.

With radii equal to F 3″, F 2″, F 1″ and F D^2, and with F in Fig. 142 as center, describe the arcs 3, 2 2, 1 1 and D D. From the center F draw the

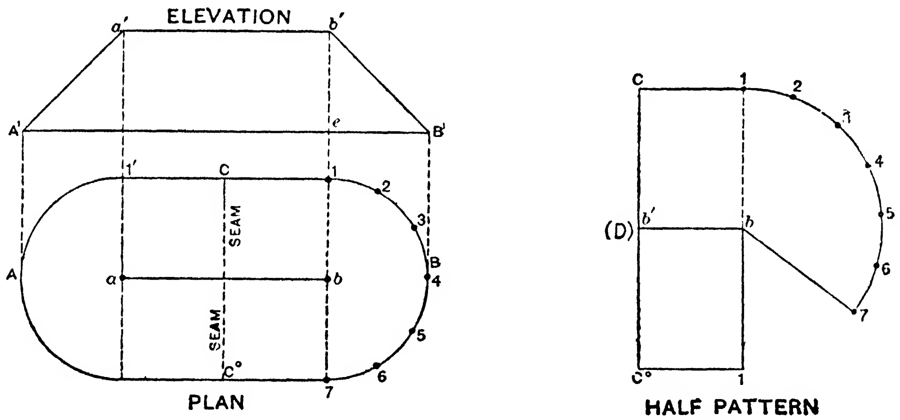


Fig. 143. Cover with Constant Flare All Around

vertical line F 3, intersecting the arc 3 at 3. Now set the dividers equal to the distances 3 to 2, 2 to 1 and 1 to D in plan in Fig. 141, and, starting from the point 3 in Fig. 142, step from one arc to another having similar numbers, thus obtaining, respectively, the points 3, 2, 1, D on both sides. Trace a line through the points thus obtained, as shown by F D 3 D F, which will be the half pattern for the cover, to which laps must be allowed for seaming. The handles shown on the boiler and cover in Fig. 140 are made with hem edges a and b in diagram X in Fig. 142. They are then riveted to the boiler and cover and soaked with solder.

In Fig. 143 is shown how to develop the pattern for a cover in two pieces, when the flare is equal all around, or, in other words, when a ridge forms in the center, as shown in plan and elevation by *a b* and *a' b'*, respectively. First draw the plan of the cover, as shown by A B, the semicircular ends being struck from *a* and *b*, as centers.

Above the plan draw the elevation *a' b'* B^1 A^1, making the hight *e b'* as desired. As the cover is to be made in two parts, a seam will take place at C C° in

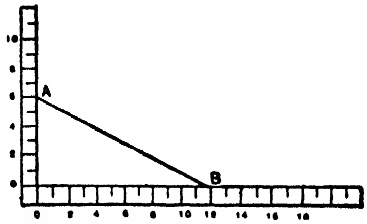


Fig. 144. Obtaining Radius from Steel Square

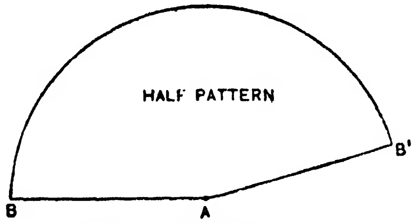


Fig. 145. One-Half Pattern

plan, as shown. Having properly drawn the plan and elevation and divided one of the semicircular ends into equal parts, shown from 1 to 7, the half pattern is obtained as shown in diagram (D), in which draw any horizontal line, C 1, equal to C 1 in plan. At right angles to C 1 in (D), from C and 1, draw C *b'* and 1 *b* equal in length to the flare *b'* B^1 in elevation. Now reproduce 1 C *b' b* opposite *b b'*. Using *b* as center, draw the arc 1 7, upon which place the girth of the semicircle in plan. Draw a radial line from 7 to *b*, which completes the half pattern.

In the following is shown a short rule for obtaining the pattern for round pitched covers of any diameter or hight. Supposing a pitched cover is desired, 24 inches in diameter and 6 inches high, and the pattern is to be laid off directly onto the metal without the use of any drawing. Then proceed as is shown in Fig. 144, which gives a diagram of a steel square with the various dimensions on same. Place one point of the compass on 6 on one arm of the square, which represents the hight, and the other point on 12, representing the half diameter; then will this distance, A B, be the radius with which to strike the pattern. Now with any point, as A in Fig. 145, as center, describe the arc B B^1. Multiply the diameter 24 by 3 1-7, which will equal 75 3-7 inches, the circumference of the 24-inch circle. Divide by 2 for the half pattern, which leaves 37 5-7 inches. Set the dividers 1 inch distant, and step off 37 1-inch spaces on the arc B B^1, starting from B. Divide the inch division on the rule into seven equal spaces and add five of these spaces on the arc B B^1. Draw a line from A to B and A to B^1, which will complete the one-half pattern for the cover.

GROCER'S OVAL FUNNEL

In Fig. 146 is shown a perspective view of an oval funnel, with a handle at *a*. Its construction is indicated in Fig. 147, in which *a a*, *c c* is oval in shape, having a wired edge at *a a*. And *d d*, *b b* is a round collar wired at *b b*. The funnel proper is a transition piece from oval to round, with edges at *c c* and *d d*.

The patterns for the top and bottom collars are straight strips of the required width and equal to the circumferences of the oval and round sections, respectively.

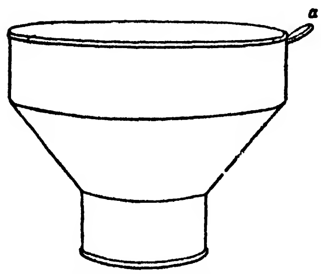


Fig. 146. General View

The pattern for the funnel is developed by triangulation, as shown in Fig. 148, in which A B C D is the plan of the oval top and E the plan of the round collar. As the four quarters are symmetrical, it is only necessary in practice to draw one quarter plan, as, for example, B.

Divide both the inner and outer curve into equal parts, as shown from 1 to 7 and 2 to 8, which connect, as shown. These lines then represent the base lines of triangles, the altitudes of which will equal the hight of the funnel. This hight is shown by 2 2′, the elevation of the funnel not being required. Take the girth of 1 2 3 4 5 6 7 8 and place it on any horizontal line, as shown from 1 to 8 in the diagram of triangles. As the points 2. 4, 6 and 8 in the plan represent the highest points,

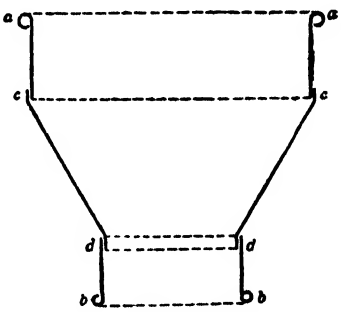


Fig. 147

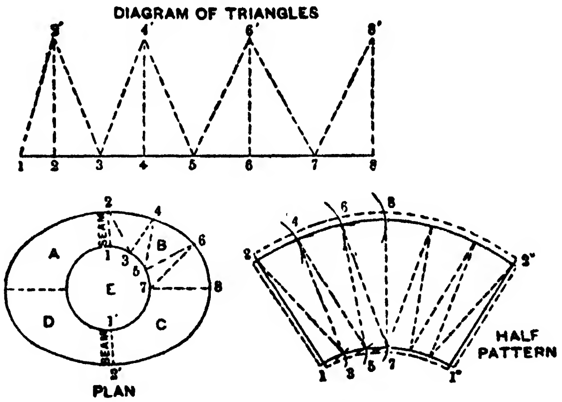


Fig. 148

Section and Method of Obtaining the Pattern

then from 2, 4, 6, and 8 erect vertical lines equal to the hight of the funnel, as shown by 2 2′, 4 4′, 6 6′, and 8 8′, and connect slant lines, as shown. The latter represent the true lengths of similar numbered lines in the plan. Thus, 3 4′ shows the true length of 3 4 in plan, etc.

The quarter pattern is obtained as follows: Take the distance of 1 2′ and place it on any line, as 1 2 in the pattern. With 1 as center, describe the arc 3,

with radius equal to 1 3 in plan. Now, with radius equal to 1′ 3, and 2 in the pattern as center, describe the arc 3, intersecting the one previously drawn at 3.

With radius equal to 2 4 in plan, and 2 in the pattern as center, describe an arc, which intersect by an arc struck from 3 as center, and 3 4′ in the triangles as radius. Proceed in this manner, using alternately as radii, first the spaces in the circle E, then the true length in the triangles, the spaces in the oval B and the proper slant lines in the diagram of triangles, until the line 7 8 in the pattern is obtained.

A line traced through points thus obtained, as shown by 2 8 7 1, is the one-quarter pattern. If the funnel is to be made in two parts, transfer 2 8 7 1 opposite the line 8 7, as shown by 8 2° 1° 7. Then 1 1°, 2° 2 will be the half-pattern, to which edges are allowed for soldering and seaming.

REVOLVING BENCH FOR TINNERS' MACHINES

A handy arrangement for the turning and similar machines used by the tinsmith is a revolving bench, so that the different machines can be used in series as they are required, as shown by Fig. 149. By revolving the bench, the machine needed next can be brought convenient to the workman and is made as follows:

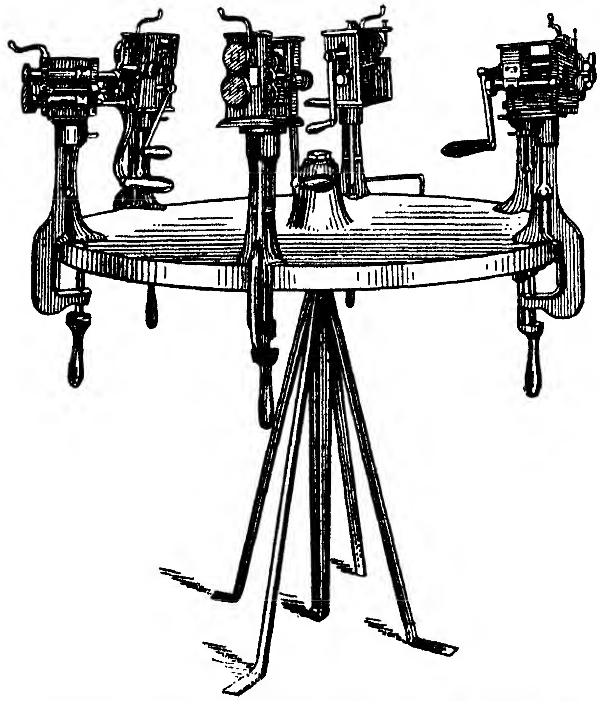


Fig. 149. Revolving Bench for Tinners' Machines

One of the wheels and part of the axle from an old wagon were purchased for a small sum and the axle was cut off, so that one end was securely fastened in the floor. It brought the top of the wheel at the right hight from the floor for a bench for the machines. Two holes were drilled through the axle below the hub of the wheel and at right angles to each other. These holes were for the bolts used for securing the top end of the braces shown in the picture, which were securely fastened by the bolts and nuts. These braces were made of ¾-in. pipe, the ends being flattened after being heated in the tinners' furnace, and the ends were also bent to the right angle to fit against the axle and on

the floor. Two holes were drilled in the bottom ends for fastening to the floor by means of wood screws. The braces held the axle in a vertical position and firmly.

The wheel was then placed on the axle, and it was a simple matter for the sheet metal worker to make a covering of sheet metal to lay on the spokes to prevent articles from dropping through and to afford a support for the work. The nut on the end of the axle is screwed down on the top of the hub tight enough to prevent the wheel from moving unless some energy is expended. By this means the machines attached to the rim of the wheel are held with sufficient steadiness for all ordinary work and yet the wheel can be turned to bring the different machines in position as they are required for work. It would be a good idea to make tin covers to slip over the machines to exclude dust when machines are not in use.

SQUARING TIN

The usual method of squaring tin by means of the squaring shears is to set the gauge for the width of the sheet, then by laying one edge of the sheet over the gauge, cut one edge. The sheet is then turned over and the cut edge brought against the gauge, when the remaining edge is cut. This operation is continued until the desired number of sheets have had their sides trimmed.

The front gauge is then moved back, say 19¾ inches from the blade. A sheet is then brought against the side gauge and one end allowed to project over the front gauge, when the end is cut. The sheet is then turned over and the cut edge brought against the front gauge, when the remaining end is cut. This double operation consumes unnecessary time, as each sheet must be handled twice, and in case it is desired to commence work with some of the tin at once, it is necessary to either wait until the tin has all been cut one way before it can be finished, or the gauge must be changed so a limited number of sheets can be finished.

In some shops the "square sheet" is used for a pattern for setting the gauge, but it sometimes happens that in trying to see if the shears are properly set a narrow strip is cut off the pattern, thus reducing its size. When setting the shears by means of the square, there is danger of injuring the cutting edges of the shear blades.

All of these difficulties can be overcome by means of simple arrangements, one of which is shown in Fig. 150. Let G H represent the shear bed, E the cutting knife and A B one of the arms. A piece of heavy sheet iron of sufficient length is placed as indicated by C D. From D to E is to be the width the sheet is to be cut. An iron gauge, C F is riveted to the iron, so the distance F E will

be the length of the sheet, say 19¾ inches. Below the end elevation the sheet iron is represented by J K, and the gauge by M. Two or more pieces of bent iron are riveted under the sheet iron, as shown at L, so as to be brought against the shear bed and thus insure the proper position of the attachment. In the plan, only

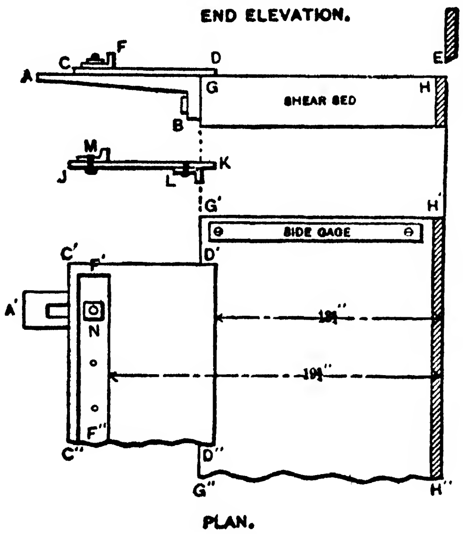


Fig. 150. Sheet Iron Gauge

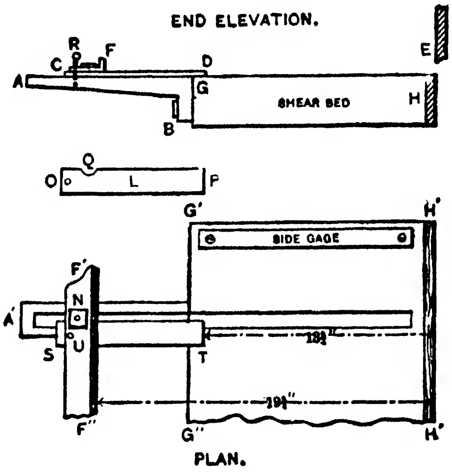


Fig. 151. Band Iron Gauge

part of the shear bed is shown, and is represented by G′ H′ H″ G″. The sheet iron is represented by C′ D′ D″ C″, and the iron gauge by F′ F″. This gauge can be made from a bar of iron having one side and edge planed true. The device can be secured to the arm A′ by a bolt at N, by slipping the edge C′ C″ under the regular gauge and screwing tight, or by any convenient means. The reader will understand that as only part of the shear bed is shown in plan, the other arm, similar to A′ is not represented.

When tin is to be squared the gauge is placed in position and secured. A sheet of tin is laid with one side between the shear blades and the other over D and the edge cut. The sheet is then turned over bringing the cut edge against D, when the side is cut. One side of the sheet is brought against the side gauge (shown in plan) and the end cut. The sheet is then turned over, bringing the cut end against F, when the remaining edge is cut. Thus the sheet is squared without laying down. If special sizes of tin are needed in quantities, as the gores for square pipe, other gauges can be made as required.

Another form of gauge, operated as above described, which can be made from two pieces of one inch band iron—such as usually comes about galvanized iron—is shown in Fig. 151. The regular sliding gauge F is used. Two pieces of band iron about 8 inches long are to be prepared, as shown by O P. The notch Q is cut

out so the iron will pass by the bolt that holds the sliding gauge in position. The ends of the band iron, as at P, are to be filed square. The pieces are to be slipped under the gauge, as shown by C D in elevation or S T in plan. The distance between ends D to shear blade E is to be equal to the width the sheet is to be cut. The sliding gauge is to be so set that the distance F E of elevation or F′ F″ to H′ H″ of plan will be equal to the length the sheet is to be cut. After the strips and sliding gauge are found to be exactly in the proper position the nuts are to be screwed up tight, and, by means of a twist drill, small holes are to be drilled through the sliding gauge, band iron and arm of shears at each of the arms. Through each hole a slightly tapering pin is passed, as indicated at R in elevation. The hole is also shown at U in plan. After the holes are drilled, if it should be found that the band iron strips are not of the exact length required, they can be lengthened by hammering on a stake, or shortened by filing. It will be found convenient to mark the strips R and L, to designate which goes to the right or left hand arm of the shears. The iron pins can be attached to the shears by means of string or chain. To set the shears for squaring tin it is only necessary to place the strips in position on the arms, and under the sliding gauge, put the two pins through the holes in gauge, strips and arms, and screw up the two bolts. By this arrangement the tin should always be of a size, which is a great convenience. Before drilling the holes it may be well to cut the sides of a sheet, then reverse its position on the shears, to determine if the sliding gauge is exactly in position.

A HOME MADE WIRE CUTTER AND REEL

This cutter, illustrated by Fig. 152, has numerous advantages, the most important feature being fast cutting, the jaws always being open and in such a position as to enable the operator to use both hands for controlling the wire, so he can cut as fast as the foot can work the treadle. A lively boy can cut from 75 to 100 gross of two-quart bucket bails in a day. The machine will cut any size of wire up to No. 6 with ease. If heavier wire is to be cut, larger shears should be used for the machine. It will be seen from an inspection of the engraving, that the cutter is a very cheap one to construct, for the reason that in most any tin shop that has been in business a number of years can be found a pair of old stock shears that can be used for the purpose. Any country blacksmith can do the iron work.

To construct the wire cutter: Fasten a piece of 2 × 12 plank, as shown at A, to the end of an ordinary work bench, and secure firmly to the end of bench

and floor. Take an old pair of stock shears and cut the blades off, leaving them about 2 inches long. Care must be taken, if they are heated before cutting, that the temper is not injured. The safest way is to cut through the iron while cold, then place in the vice and strike on the steel side with a heavy hammer, thus breaking off the ends. The rough edges can be ground on an emery wheel. Next cut the handles off, leaving the one to be attached to the lever 6 inches longer than the other. Put a ½-inch steel pin in the longer handle, letting it project 1½ inches, as shown at E. The shears B are to be fastened to the plank A by two ½-inch bolts, through holes in handle at C and D. Take a piece of ½×1¼-inch iron 26 inches long and bend off 6 inches at right angles, as shown. Then cut a slot at F in end 9-16×1½ inches to receive the steel pin E. Flatten out the other end, as shown at I, for a foot piece. Drill a hole at G for a ¾-inch bolt, which secures treadle to plank A. The guard H is made from a piece of ¼×1-inch iron, bent as shown, and secured to the plank A by means of screws or bolts at M and N. J is a spring made of No. 8 spring wire, and when finished should be 9 inches long and 1½ inches in diameter. It is secured to plank by a screw at O, the other end being turned over so as to pass through the opening in treadle at P. The wire holder K can be made of 1½×1½ angle iron, and bent to the required curve while hot, or it can be made of cast iron. The length of holder K will depend upon length of wire to be cut. The gauge L, which slides on the holder K, is provided with a set screw for securing it in any desired position.

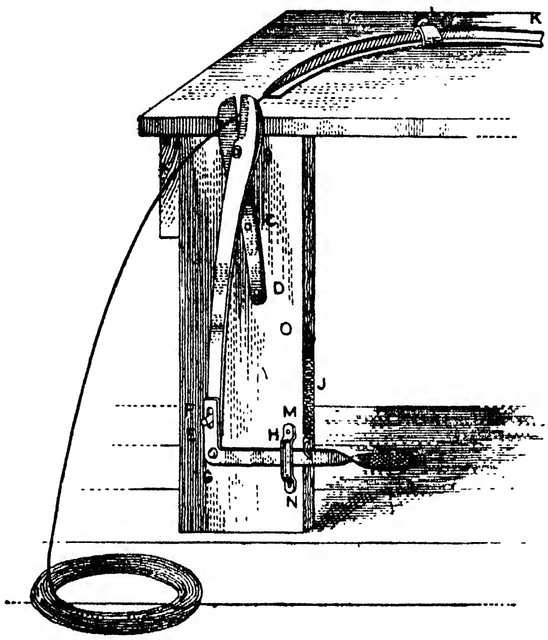


Fig. 152. General View of the Cutter

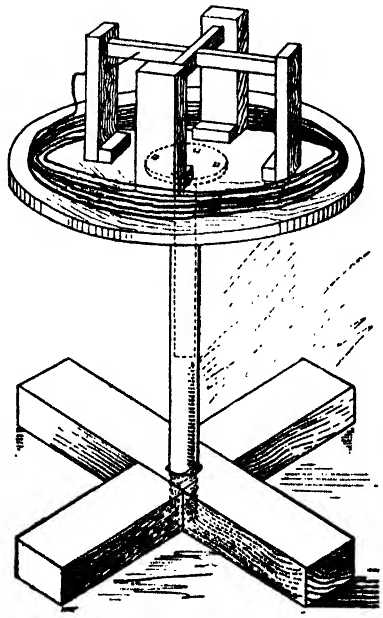


Fig. 153. General View of the Reel

Pattern for Center Funnel Oval to Round

In Fig. 155 is shown the method of obtaining the patterns for the oval funnel and round spout and 1′ 1″ 9ᵛ 9 shows the elevation of the funnel and 9 9ᵛ 10ᵛ 10 the elevation of the spout. The shape of the funnel at the top is shown by the plan of the top, while the half section on 9 9ᵛ is shown by 9 6 9ᵛ and is struck from the center 6′. Through the center of the elevation and plan draw the center line A B and lengthwise through the plan the center line C D. Divide one half of the semi-circle into equal spaces as shown by the small figures 6, 7, 8 and 9. Extend the side of the spout 9 10 until it meets the center line A B at E. Then using E as center and radii equal to E 10 and E 9, draw the arcs 10ᵛ 10ᵃ and 9ᵛ 9ᵃ respectively. On the outer arc establish any point as 9″, from which draw a line to the center E intersecting the inner arc at 10″. Take four times the girth of the quarter circle 9 to 6 in the elevation and place it on the outer arc 9ᵛ 9ᵃ, starting from the points 9″, thus obtaining points from 9″ to 6 to 9 to 6 to 9ᵃ. From 9ᵃ draw a line to the center E, cutting the inner arc at 10ᵃ and 9″ 9ᵃ 10ᵃ 10″ then shows the pattern for the spout without any laps.

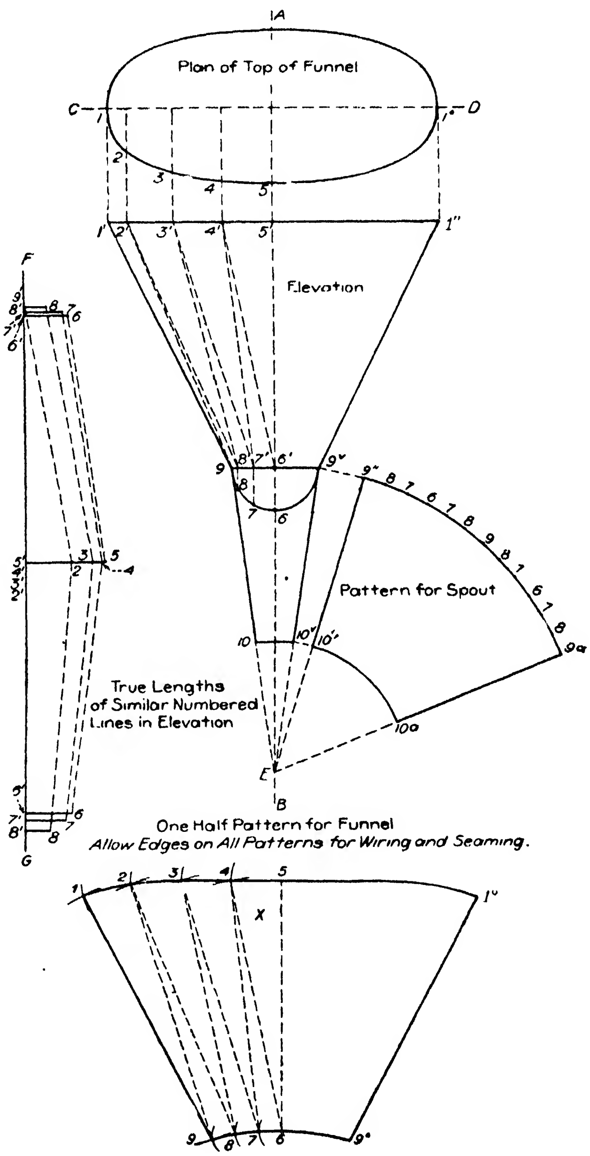


Fig. 155. Obtaining Pattern for an Oval to Round Funnel

As the funnel is oval at the top and round at its base, the pattern will be developed by triangulation as follows: Divide the one quarter oval plan into equal spaces as shown from 1 to 5, from which points and at right angles to C D draw lines intersecting the line C D,

as well as the top line 1′ 1″ in elevation as shown by the small figures 1′ to 5′. As there are four spaces in the quarter oval, and but three spaces in the quarter circle, connect 5′ and 4′ to 6′ and the rest of the points by lines as shown. These lines then represent the bases of sections which will be constructed, the altitudes of which are equal to the various perpendicular heights in the quarter oval and quarter circle. For example: to find the true length of the line 3′ 7′ in elevation, take this distance and place it on the vertical line F G as shown from 3′ to 7′. From these two points and at right angles to F G draw the line 3′ 3 and 7′ 7 equal respectively to the distances measured from the line C D in the quarter oval to the point 3, and from the line 9 9ᵛ in the semi-circle to the point 7. A line drawn from 3 to 7 in the diagram of true lengths will give the true length of the line 3′ 7′ in the elevation.

Assuming that the funnel is to be made up in two parts with a seam at 1 and 1° in the plan, start the half pattern by taking the distance 5 6 in the true lengths and placing it as shown by 5 6 in the pattern X. Now using 5 4 in the half plan as radius and 5 in X as center describe the arc 4, which intersect by an arc struck from 6 as center and the true length 6 4 as radius. Then with 6 7 in the semi-circle in elevation as radius and 6 in X as center describe the arc 7, which intersect by an arc struck from 4 as center and 4 7 in the true lengths as radius. Proceed in this manner, using alternately first the divisions in the oval plan, then the proper true length,—the divisions in the semi-circle in the elevation, then again the proper true length, until the line 1 9 in the pattern has been obtained, from 1′ 9 in the elevation. Trace this quarter pattern 1 5 6 9 opposite the line 5 6 as shown by 1° 9°. Then 1 1° 9° 9 will be the half pattern for the funnel to which edges must be allowed for seaming and wiring.

Pattern for Funnel, Perpendicular at One End

In Fig. 156 is shown how the patterns are developed for a funnel, the top of which is oval and the spout round, and when one end of the funnel is perpendicular. First draw the side elevation of the funnel as shown, making the pitch as desired. Draw the oval section of the top of the funnel as shown above the elevation, representing the true section on the line 1′ 11′ in the side elevation. On the joint line 12 16, between the funnel and spout draw the semi-section E. In this case the spout is a parallel piece of tubing as shown. The first step is to divide the half section of the funnel into equal spaces as shown by the small figures 1 to 11. Note that where the curves are struck with a short radius, as at the ends of the oval between 1 and 3 and 9 and 11, the spaces are smaller than between 3 and 9.

Through the center of the oval draw the lines A B and C D. At right angles to A B and through the small figures 1 to 11 draw lines meeting the line A B, as well as the top line of the funnel in elevation as shown from 1′ to 11′. In a similar manner divide the semi-circle E into equal spaces, in this case four, as shown by

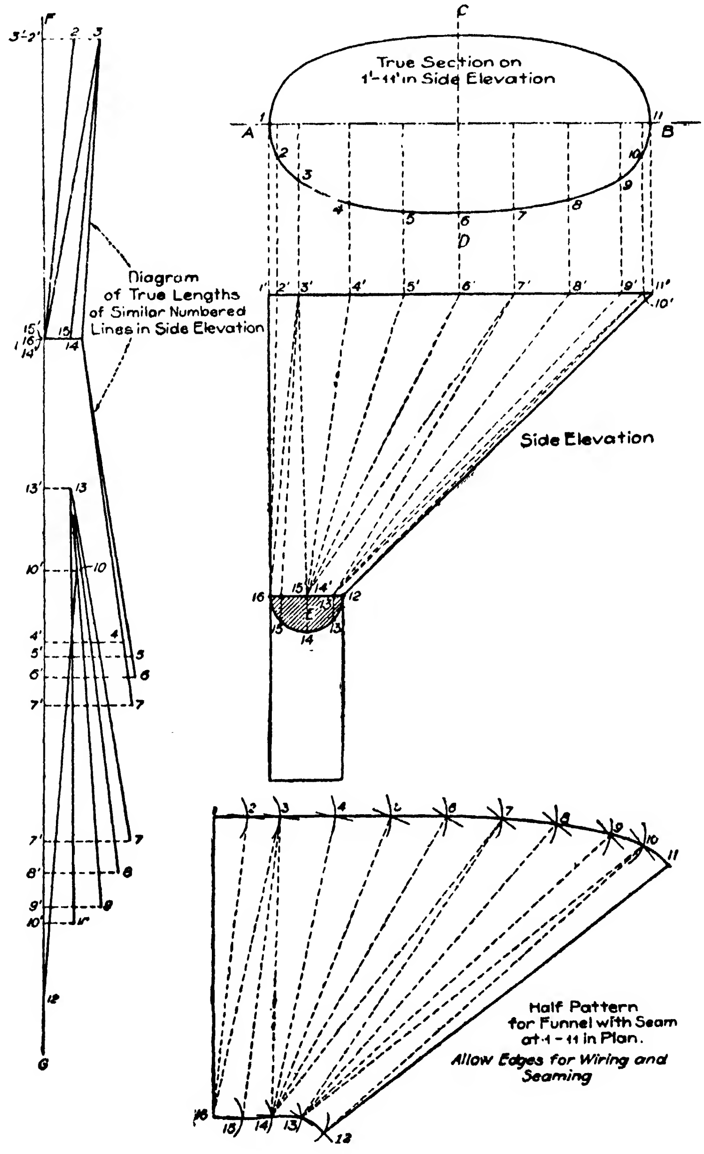


Fig. 156. Elevation, Plan and Pattern for Funnel Perpendicular at One End

the small figures 12 to 16 from which points perpendiculars are drawn, meeting the line 12 16, at 13′ 14′ and 15′. As the semi-oval contains a greater number of spaces than the semi-circle, then connect the various numbered points by lines

in a manner as shown in the side elevation. These lines then represent the base lines of sections which will be constructed, with altitudes or heights equal to the various distances measured from the line A B to points 2 to 10 in the half oval and from the line 12 16 to points 13 to 15 in the half circle E, all as shown in the diagram of true lengths. For example, to find the true length of 14′ 6′ in the side elevation, take this distance and set it off on the line F G as shown from 14′ to 6′. From these two points and at right angles to F G, draw the lines 14′ 14 and 6′ 6 equal in length to the distance measured from the line A B to the point 6 in the half oval and the distance of 14′ 14 in the semi-circle E. The length of the line drawn from 6 to 14 in the diagram of the true lengths, will give the true length of the line 14′ 6′ in the side elevation. In this manner all of the true lengths shown, are obtained.

When the half pattern is being laid out the direction of the lines in elevation must be followed so that the lines will run in a similar manner in the pattern. First take the length of 1′ 16 in elevation which shows its true length, and place it as shown by 1 16 in the pattern and with radii equal to 16 2 and 16 3 in the true lengths and 16 in the pattern as center, draw the arcs 2 and 3. Set the dividers equal to the distance 1 2 and 2 3 in the half oval and starting from 1 in the pattern, intersect arc 2, then arc 3. Then using as radii the distances 3 15 and 3 14 in the true lengths and 3 in the pattern as center, describe the arcs 15 and 14, which intersect by the divisions obtained from 16 15 and 15 14 in the semi-circle E. Procced in this manner in completing the pattern, using alternately first the radii in the true lengths, then the divisions in the semi-oval, again the proper radii in the true lengths, then the divisions in the semi-circle, E, until the line 11 12 in the pattern has been obtained, which equals 11′ 12 in the side elevation. Trace a line through points thus obtained in the pattern, and 1 11 12 16 will be the half pattern for the oval funnel with a seam at 1 and 11 in the oval section. Seaming and wiring edges must be allowed to the pattern.

Patterns for a Rectangular Funnel

Fig. 157 shows how the rectangular funnel is laid out. When this funnel is made in large sizes, the four sides are usually seamed together separately, but when the funnel is small, the pattern may be laid out in one with just one corner seamed. Both patterns will be laid out as we proceed. First draw the side elevation of the funnel as shown by A B C D and above this draw the plan view E F G H, which shows the plan view on the line A D. The plan view on B C in elevation is shown by J K L M. Thus the top of the funnel is rectangular while the bottom

is square. To the square bottom J K L M the tapering spout is soldered as shown in elevation by Y.

The pattern for the spout Y has not been shown here, as this same pattern was developed in Fig. 155. As D C in the side elevation shows the true length of the ends of the funnel at right angles to F E or G H, it will be necessary to find the true length of the sides, because no elevation of the end is shown. Therefore, take the distance of the projection of the side J a in plan and place it from the vertical line erected from B in elevation as from J^1 to a'. A line drawn from a' to B will give the true length of the sides at right angles to F G or E H in plan. From the center i in plan draw the horizontal line C° D° and the perpendicular line B° J°. Take the girth from C to D in elevation, and place it as shown by C° D°, through which and at right angles to C° D° draw lines as shown, which intersect by lines drawn parallel to C° D° from the corners E F K and L in plan. Connect the various intersections by lines and then N O P R will be the pattern for the ends. In a similar manner obtain the patterns for the sides. Take the distance of B a' in elevation and place it on the vertical line as B° J°. Through these points B° and J° draw the usual measuring lines, which intersect from the proper corners in plan as shown and S T U V will then show the pattern for the sides.

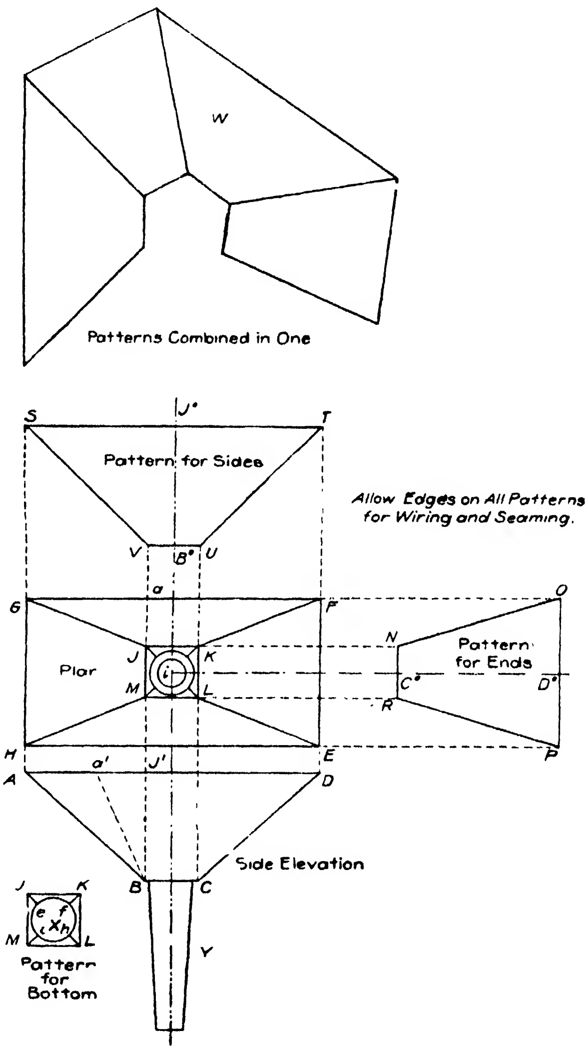


Fig. 157. Elevation, Plan and Pattern for a Rectangular to Square Funnel

If the patterns have been accurately developed, the length of the miter T U in the side must equal the length of the miter N O in the end. If the funnel is small it may be made without waste of material, the side and end patterns being joined in one as shown in diagram W.

In X, J K L M shows a reproduction of similar letters in plan. The circular opening X is cut out, to which the spout Y in elevation is flanged and soldered. Before the bottom X is soldered to the funnel the corners are slightly creased from J to *e*, K to *f*, L to *h* and M to *i* by setting over the hatchet stake with the mallet. Edges should be allowed on all patterns for wiring and seaming.

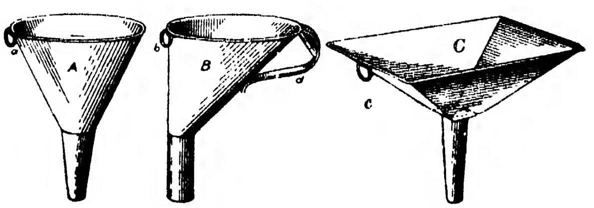


Fig. 158. Finished View of the Three Types of Funnels Previously Described in Figs. 155, 156 and 157

The three types of funnels just described in Figs. 155, 156 and 157 are shown in perspective in Fig. 158 by A, B and C respectively. Wire rings are attached at *a* *b* and *c* or sometimes the handle *d* is attached to the shaped funnel B.

Pattern for Combination Measure and Funnel

In Fig. 159 is shown a finished view of a combination measure and funnel. The method of developing these patterns excepting the handle will be explained in the detail drawing shown in Fig. 160, in which the center line A B is first drawn, and on which the height of the measure C D is set off. On either side of C D set off the semi-diameters of the top and bottom as shown by C 8, C 8^x and D E, D E° respectively. On the top line of the measure draw the side elevation of the funnel, making it of the shape desired, as shown by 1 5 8 9 *i'* *i* 13 1. Below the bottom of the measure draw the plan view on the line E E° as shown, the circle being struck from the center A, through which draw the horizontal line *a* *f* and divide the semi-circle into equal spaces as shown from *a* to *f*. Using C on the upper line of the measure 8 8^x as center, and C 8 as radius, draw the arc, which intersect at 5′ by a line drawn at right angles to C 8 from the established point 5 of the funnel. This gives the true distance from 5 to 5′, which is laid off from 5 to 5° at right angles to 5 1, and from 5° a quarter elliptical shape 5° 1 is drawn at pleasure.

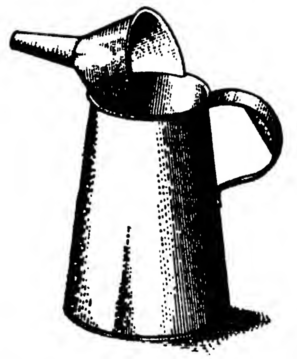


Fig. 159. View of Finished Measure and Funnel

Bisect the joint line 9 13 between the funnel and the spout and obtain 11, which use as a center and describe the semi-circle 9 11° 13, which on account of its small size, is divided into but four spaces, as shown by the small figures 10° 11° and 12°. Through these small figures, at right angles to 9 13, draw lines intersecting the joint line 9 13 at 10, 11, 12. In a similar manner divide the sections

U and T into equal spaces as shown from 1 to 5° and 5′ to 8 respectively From these points, at right angles to 1 5 and 5 8 draw lines intersecting the funnel line

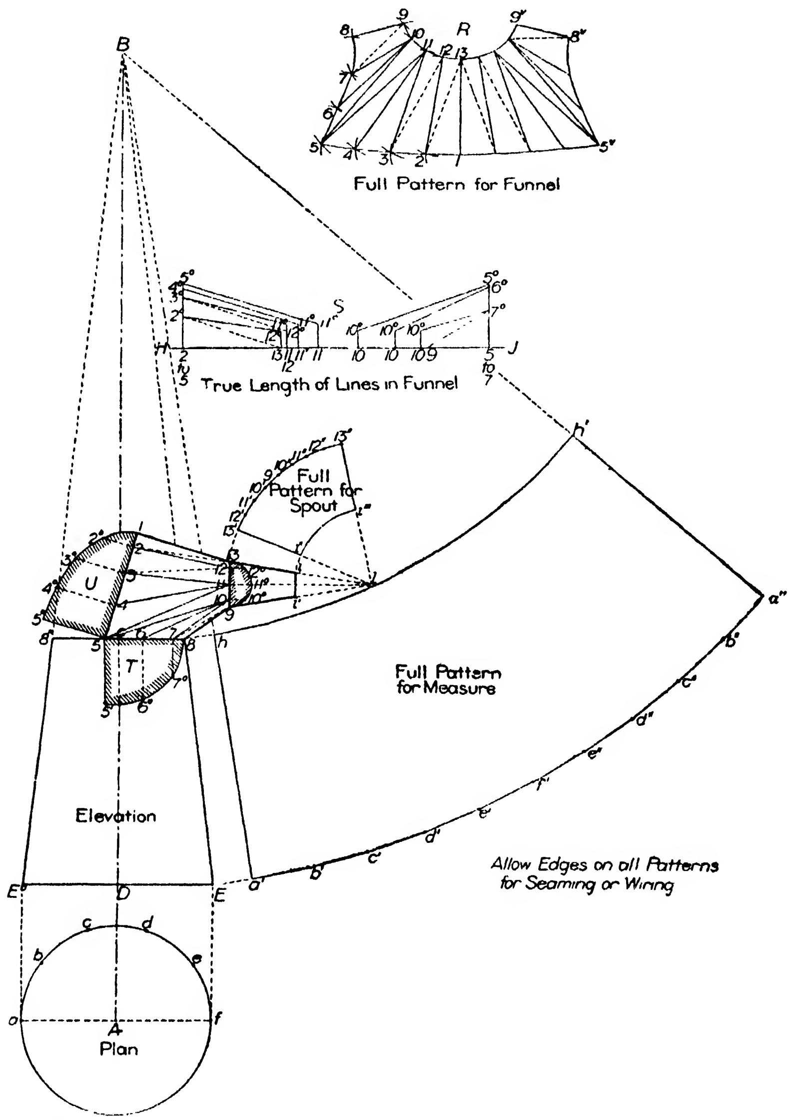


Fig. 160. Details for Laying Out Combined Measure and Funnel

1 5 and 5 8 at 2, 3 and 4, and 6, and 7 respectively. Connect the various points between 1 and 8 to the points between 9 and 13 as shown.

Then will these lines in the funnel elevation, represent the bases of sections which will be constructed in diagram S, the altitudes of which will equal the various heights shown in the profiles T and U, also the semi-circle.

To find the true length of, say, 11 4 in elevation, simply place this distance as shown on H J from 4 to 11′. From 4 and 11′ erect the lines 4 4° and 11′ 11°

equal respectively to the heights 4 4° in the profile U and 11 11° in the semi-circle. A line drawn from the points 4° to 11° in the true lengths S will be the true length of the line 4 11 in elevation. In this manner all of the true lengths are obtained in diagram S.

The pattern for the funnel is laid out as shown in diagram R as follows: Take the length of 1 13 in elevation and place it as shown by 1 13 in R. Now with 1 2° in the profile U as radius, and 1 in R as center, describe the arc 2, which intersect by an arc struck from 13 as center and 13 2° in S as radius. Then using 13 12° in the semi-circle as radius and 13 in R as center, describe the arc 12, which intersect by another arc struck from 2 as center and 2° 12° in S as radius. Proceed in this manner, using alternately, first the divisions in the profile U, then the proper true length; the divisions in the semi-circle in elevation, then again the proper length in S, until the line 11 5 in the pattern R has been obtained. Starting from the point 11 in R, use the divisions in the semi-circle in elevation as radius, then the true lengths in S; the divisions in the profile T, then again the proper length in diagram S, until the line 8 9 in R has been obtained, which is equal to 8 9 in the elevation. Trace a line through points thus obtained, then will 1 5 8 9 13 be the half pattern for the funnel. Trace this half opposite the line 1 13 as shown by 5^v, 8^v, 9^v which completes the full pattern.

The full pattern for the spout is shown by 13′ 13″ *i‴* *i″* and is struck from the center *l*, which is obtained by extending 13 *i* and 9 *i′* until they intersect at *l*. Twice the girth of the semi-circle 9 13 is placed along the outer curve 13′ 13″ as shown.

The pattern for the measure is obtained by extending the sides of the measure until they intersect at B, which use as a center and with B 8 and B E as radii describe the arcs shown. Starting from *a′* on the outer arc, set off twice the division in the plan, as shown from *a′* to *f′* to *a″*. From *a′* and *a″* draw lines to the apex B, cutting the inner arc at *h* and *h′*. Then will *h h′ a″ a′* be the full pattern for the measure.

On all patterns edges must be allowed for seaming and wiring.

SECTION IV

(Pages 437-542)

CONDUCTORS, LEADERS AND LEADER HEAD LAYOUTS

Practical Sheet Metal Work and Demonstrated Patterns

PATTERN FOR GUSSET SHEET

For a gusset sheet marked S in Fig. 1, first draw the end elevation A, showing a section of the pipe, and in its proper position the elevation of the pipe B C D E, whose section is shown at F. Divide this section F into equal spaces, as shown by the small figures 1 to 7. From these points, parallel to B C, draw lines intersecting the circle A from B to E. In its proper position in relation to the end elevation draw the side elevation of the pipe A^1, and establish the top of the pipe H G, as shown, above which place a duplicate of the section F, as shown at F^1, which also divide into similar number of spaces, changing the position of numbers, as shown. At right angles to H G, from the various intersections 1 to 4 in F^1, draw lines, which intersect by lines drawn from similar numbered intersections in A at right angles to E D, resulting in the intersections 1′, 2′, 3′, 4′ in A^1, through which trace the miter line shown. Establish the distance G 7′, and draw a straight line from 4′ to 7′, which represents the miter line between the gusset sheet and the small pipe.

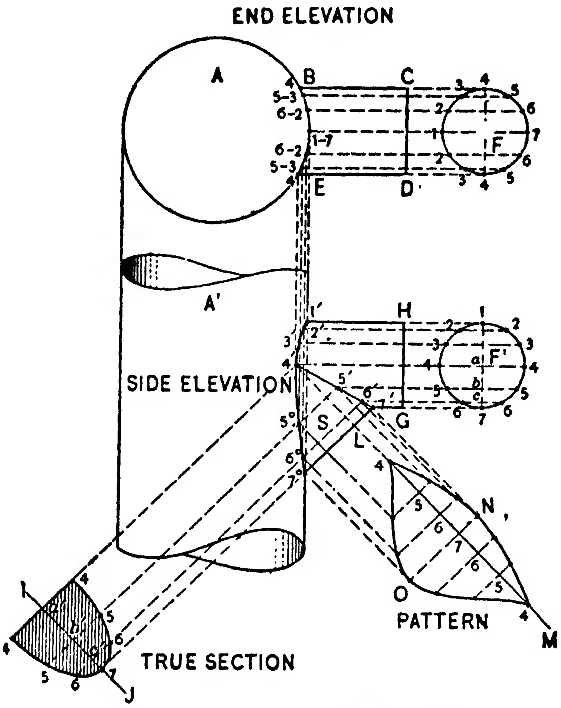


Fig. 1. Pattern for Gusset Sheet

To obtain the miter line between the gusset sheet and pipe proceed as follows: From the various points of intersections 4 to 7 in F^1 draw horizontal lines intersecting 4′ 7′ at 4′, 5′, 6′ and 7′. Draw 7′ 7° of the required length, intersecting the top of

the large pipe, or a line drawn from 7 in A at right angles to E D. From the various points 4', 5' and 6, parallel to 7' 7°, draw lines indefinitely, as shown, which intersect by lines drawn from similar numbered intersections in A at right angles to E D, resulting in the intersections 4', 5°, 6°, 7°, through which trace the irregular curve shown. The next step is to obtain a true section on 4' L, which is drawn at right angles to 7' 7°. At right angles to the lines drawn from 4' to 7' draw I J. Now measuring in each instance from the center line 1, 7 in F^1, take the various distances from *a* to 4, *b* to 5 and *c* to 6 and place them on either side of I J on similar numbered lines, as shown from *a'* to 4, *b'* to 5, *c'* to 6, 7 being the highest point. Trace a line through points thus obtained; then will the shaded part be the desired section.

For the pattern for the gusset sheet, draw any line, as L M, at right angles to 7' 7°, upon which place the stretchout of the true section, being careful to measure each space separately, as they are all unequal. Through these points draw lines at right angles to L M, which intersect by lines drawn parallel to L M from similarly numbered points of intersections on the joint lines 7' 4' and 4' 7°. Trace a line as shown by 4 N 4 O, which is the desired pattern, to be formed after the true section.

If it is desired to make the section on 4' L in S a true semiellipse, the shaded section on 4, 7, 4 must first be drawn, making 4, 4, the minor axis, equal to the diameter of the pipe marked F', and *a'* 7, the semi major axis, equal to 4' L. If planes perpendicular to the vertical plane are then passed through S and both cylinders, parallel to 7° 7', points through which to draw the miter lines on both pipes will be obtained. The miter lines will both be curved lines, and the pattern may be developed as above described. While this method is a much more difficult problem in projection, it results in making a more graceful miter line on 4' 7' and theoretically a stronger job.

PATTERN FOR A SOIL PIPE CONNECTION

This is a connecting piece to soil pipe of a square paneled leader as shown in Fig. 2, in which A B C D is the front of the paneled leader, the section of same being shown by E, and F I H B the cast iron pipe. K shows the offset required to join the square leader with the round hub. J is the section of the iron pipe. L M N O shows the side view of the square pipe, offset and iron pipe, P indicating the distance that the iron pipe sets off from the wall, and R the required hight of the offset.

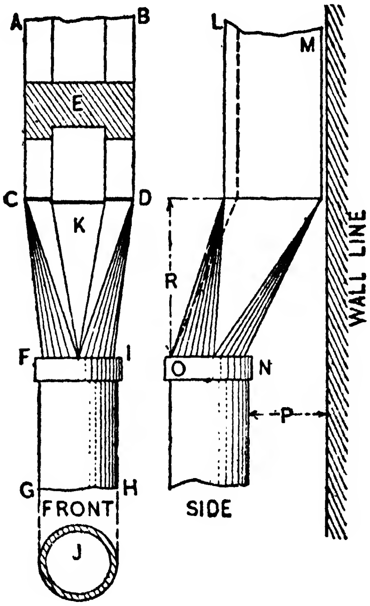


Fig. 2

When getting out the shop pattern it is not necessary to draw the front or side view of the offset. All that is necessary is a plan view, as is shown in Fig. 3. Then, knowing the hight of the offset, the triangles will be constructed as will be described in connection with Fig. 4.

Thus in Fig. 3, let 1, 2, 3, 4, 4′ 3′ 2′ 1′ be the plan view of the square paneled leader, and 5, 8, 11, 8′ the plan view of the hub of the cast iron pipe, P representing the distance that the iron pipe projects beyond the back of the square leader. As the iron pipe is central below the square leader, it is only necessary to divide one-half of the round plan as follows: Divide the quarter circles 5 8 and 8 11 into equal spaces, as shown by the small figures 5 to 11. From the corner of the square pipe 1 draw lines to 11, 10, 9 and 8, and from the corner 2 draw lines to 8, 7, 6 and 5. In similar manner from the corners 3 and 4 draw lines to the point 5 in the round pipe. The corner lines can be duplicated on the other half, if so desired. These lines form the bases of the triangles shown in Fig. 4. Erect any line, as 1 1′, equal to the hight that the offset is to have, as at R in Fig. 2. At right angles to 1 1′ and from 1 and 1′ draw lines indefinitely, as shown. Now take the various distances in Fig. 3 of 1 11, 1 10, 1 9 and 1 8 and place them on the horizontal line in Fig. 4 as shown by similar numbers, measuring in each instance from the point 1. Then from points 11, 10, 9 and 8 draw lines from the apex 1′. To avoid a confusion of lines erect another vertical line, as 2 2′. Then take the various distances in Fig. 3 of 2 8, 2 7, 2 6 and 2 5, and place them on the horizontal line in Fig. 4 as shown by joints 8, 7, 6 and 5, measuring from the point 2. Then draw lines to the apex 2′. From the point 5 erect the vertical line 5 5′. Take the lengths of the two lines in Fig. 2, 5 3 and 5 4, and measuring from the point 5′ in Fig .4 by the same method obtain the points 3 and 4, from which draw lines to the apex 5.

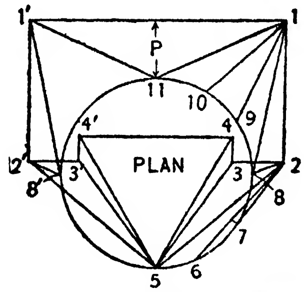


Fig. 3. Plan and Bases of Triangles

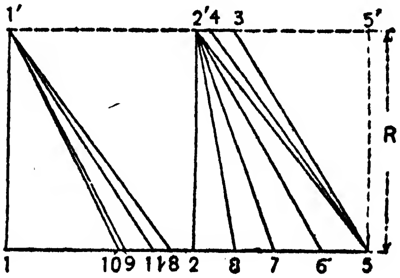


Fig. 4. Diagram of Triangles

Then will these lines or hypotenuses represent the actual distances on the finished article on lines having similar numbers in Fig. 3. For the pattern proceed as is shown in Fig. 5. Draw any horizontal line, as 1 1′, equal to 1 1′ in Fig. 3. Now with 1′ 11 in Fig. 4 as radius and 1 and 1′ in Fig. 5 as centers describe arcs intersecting each other in 11. Now with radii 1′ 10, 1′ 9 and 1′ 8 in Fig. 4 and 1 in Fig. 5 as center describe arcs, as shown by 10, 9 and 8. Now set the dividers equal to the spaces into which the half circle in Fig. 3 is divided, and starting from the point 11 in Fig. 5 step from one arc to another, thus obtaining points 10, 9 and 8. From 8 draw a line to 1. Now with 1 2 in Fig. 3 as radius and 1 in Fig. 5 as center describe the arc 2, which intersect by an arc struck from 8 as center and 8 2′ in Fig. 4 as radius. Now with 2′ 7, 6 and 5 in Fig. 4 as radii and 2 in Fig. 5 as center describe the arcs 7, 6 and 5. Then set the dividers equal to the spaces in the half circle in Fig. 3, and starting from the point 8 in Fig. 5 step from one arc to another, thus obtaining the points 7, 6 and 5. From 5 draw a line to 2. Now with 2 3 in Fig. 3 as radius and 2 in Fig. 5 as center describe the arc 3, which intersect by an arc struck from 5 as center with 5 3 in Fig. 4 as radius. Draw a line from 5 to 3 in Fig. 5. Now with 3 4 in Fig. 3 as radius and 3 in Fig. 5 as center describe the arc 4, which intersect by an arc struck from 5 as center with 5 4 in Fig. 4 as radius. Draw a line from 5 to 4 in Fig. 5. Now with 4 4′ in Fig. 3 as radius and 4 in Fig. 5 as center, describe the arc 4′, which intersect by an arc struck from 5 as center and 5 4 as radius. Draw a line from 4 to 4′ and from 4′ to 5. Now take a tracing of 1, 2, 3, 4, 4′ 5, 8, 11 and place it opposite the line 1′ 11, as shown by 1′ 2′ 3′ 4′ 5′ 8′ 11. Then will 4′ 1′ 1 4′ 5 11 5′ be the complete pattern. Allow lap, as shown.

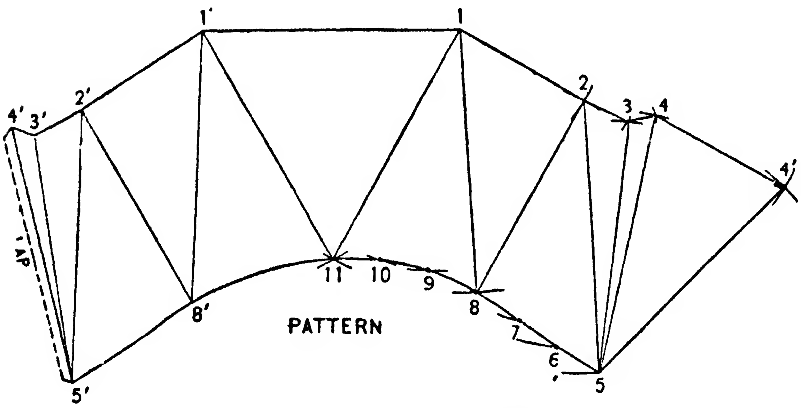


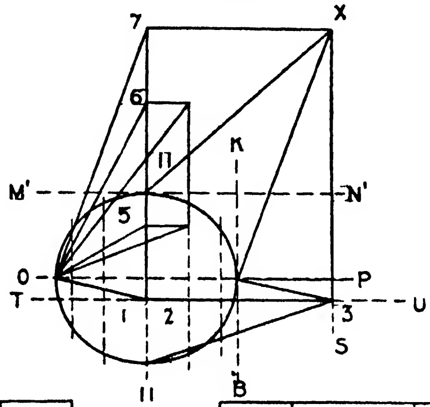
Fig. 5. The Pattern Shape

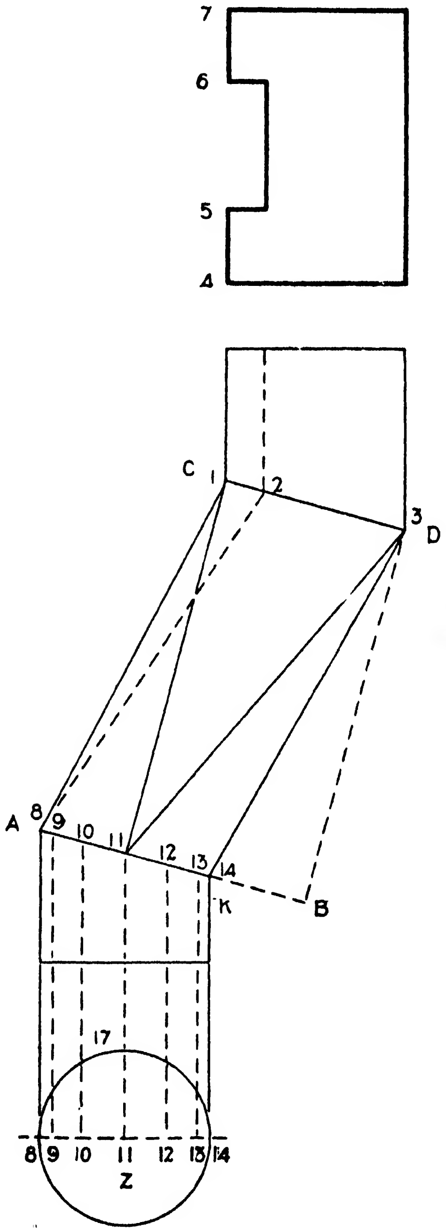
A more practical and better appearing connecting piece would be one designed as Fig. 6. The side elevation shows that it is made of three pieces allowing for greater ease when connecting to soil pipe, especially so if soil pipe is quite a distance from wall.

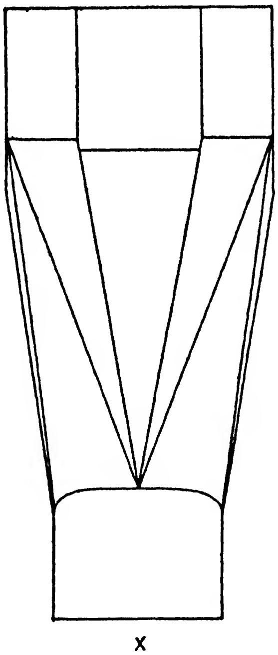
As there are no rules to follow when establishing miter lines A B and C D, Fig. 6, they were made parallel to permit the application of the same principles of

cutting as in the foregoing Fig. 3 and 4. It is evident though that sections are changed when viewed at right angle to miter lines, hence it is necessary to obtain true sections, and place them in correct position relative to Fig. 3. As it is within the range of possibility that a double offset may be required as Fig. 8, the method of

Fig. 9







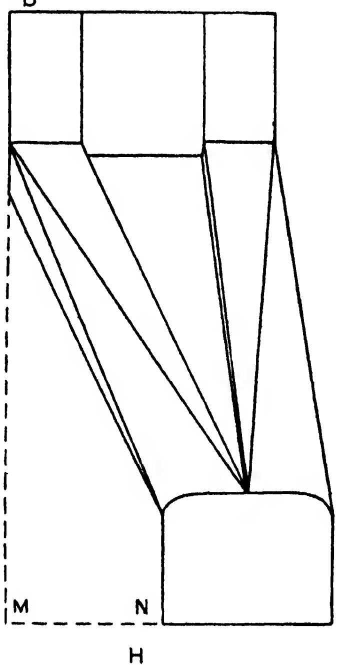


Fig. 7

Fig. 8

Fig. 6

obtaining and placing in position the section of Fig. 8 will be described, believing that from this and Fig. 3, the reader will understand the process for section of Fig. 7.

On line T U, Fig. 9, place the spaces 1, 2, 3 of C D, Fig. 6; erect verticals from these points, and from line T U on vertical from 1 place the space 4 5 of Fig. 6, repeat on 2 and 3, thereby realizing true section on C D, Fig. 6. From X S, Fig. 9, draw a parallel line the distance away of K B of Fig. 6. From T U draw line M′ N′, Fig. 9, taking distance of M N of H, Fig. 8. The line O P is drawn parallel to M′ N′ the distance of radius of profile Z of Fig. 6. On this line O P mark the space 8, 9, 10, 11, 12, 13, 14 of A B, Fig. 6, erect verticals and on each side of O P on like numbers place the spaces of, for instance, 11 17 of Z, Fig. 6. Through these points draw the ellipse which is true section of A B, Fig. 6.

For the pattern of offset Fig. 7 the exact procedure of Fig. 3 and 4 is followed, but for Fig. 8 as will be seen by Fig. 9 the plan cannot be divided into two similar halves, so a system of triangles is necessary for entire plan--still following through the principle of Fig. 4. If leader is not paneled, but square, the same method as foregoing is followed.

PATTERN FOR A REINFORCING BOSS

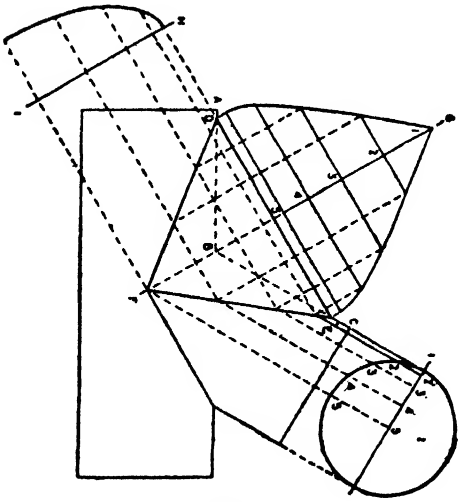


Fig. 10

In conductor work it is often required that elbows, branches, etc., be strengthened and this problem is a boss to stiffen the joint of a branch of two pipes of equal diameter. In a foregoing problem we had the same but under the title of a gusset sheet and giving a different method of obtaining the miter line and for pipes of different sizes. This method can be applied to pipes intersecting at any angle, or, of course, to reinforce the throat of elbows.

Draw the elevation of branch as shown and profile Z, Fig. 10. Bisect angle A B C and at right angle to the line G F and at pleasure in respect to the size of the boss draw line D E and lines, E F D F. Divide one-quarter of Z as 1, 2, 3, 4, 5 and drop lines to E F and parallel to D E continue them indefinitely. Draw line H I and from this on like numbered lines place spaces 1 2 2′, etc. Obtaining one-half section of boss on line G F. On line G F place stretchout of this section and draw usual lines through these points. From lines D F and E F project lines to stretchout which will give one-half of the pattern.

SHORT RULES FOR DEVELOPING ELBOW PATTERNS

In the following article short rules will be illustrated and described for developing the practical forms arising in the sheet metal shop when laying out patterns for leader elbows, roof connections, etc. While these patterns are usually developed on paper on the drafting table, the method will be described as to how to develop the patterns direct onto the sheet metal without the aid of any drafting instruments other than the ordinary mechanical tools used in the shop. The method of finding the rise of the miter line by means of the protractor for any size

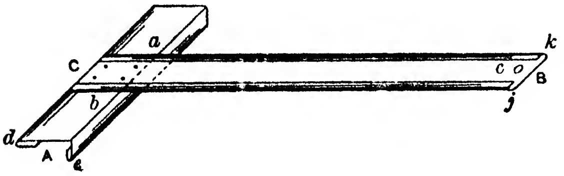


Fig. 12. Sheet Metal Tee Square

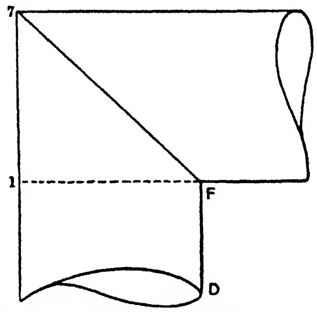


Fig. 13. 90-Degree Elbow

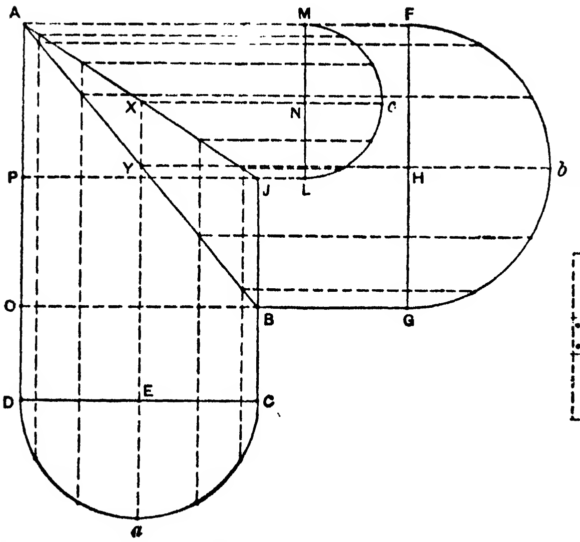


Fig. 11. Elevation of Elbows, Showing Principle involved

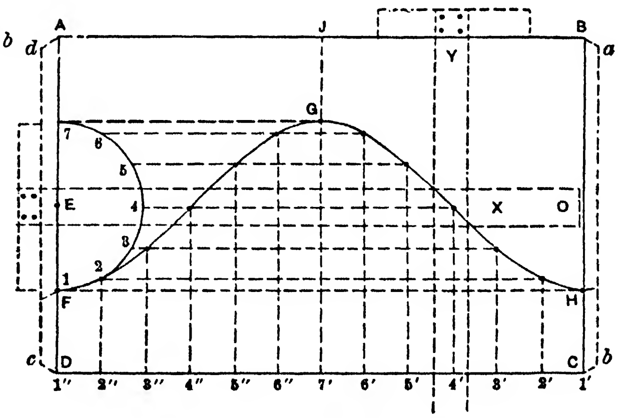


Fig. 14. Pattern for 90-Degree Elbow

elbow, no matter what the throat, diameter or number of pieces may be, will be explained, so that the laying out of any size elbow becomes a simple matter, avoiding all unnecessary drawing except what is done directly on the sheet metal.

In applying this method of development the principle to be followed is that shown in Fig. 11. Let A B C D represent the elevation of a cylinder whose half profile or section is shown by D *a* C. This semiprofile D *a* C is divided into any number of equal parts, as shown, from which point lines are erected until they cut

the oblique line A B. From A, Y and B horizontal lines are drawn until they meet the vertical line F G (which is drawn at pleasure) at F, H and G respectively. Using H as a center with radius equal to either H F or H G the semicircle F *b* G is described. From the various intersections between A and Y and between Y and B draw horizontal lines intersecting the semicircle F *b* G, as shown. By measurement it will be found that the spaces in the semicircle, F *b* G are equal.

This being true it proves that when the rise of the miter line in any elbow is known (as A O in this case) it is only necessary to place this rise in its proper position, as shown by 7, 1 in Fig. 14 to describe the semicircle, using E as a center, and to divide the semicircle into equal spaces and to find the miter cut shown, which will be described in detail as we proceed. It is immaterial what rise the miter line may have, the same principal is used, as shown in connection with the oblique line A J in Fig. 11. Extend the lines drawn from the semiprofile D *a* C, Fig. 11, until they intersect the miter line A J. From A, X and J horizontal lines are drawn cutting the vertical line M L at M, N and L. With N as center, draw the semicircle M *c* L, and intersect it by horizontal lines drawn from the points on the oblique line A J. By measurement it will be found that the semicircle M *c* L contains equal spaces, which would be used in obtaining the pattern for an elbow whose rise of the miter line would be equal to A P.

As mentioned above the patterns are to be laid out direct onto the sheet metal, and to save loss of time in using a steel square a sheet metal T-square should be constructed, as shown in Fig. 12, in which the head A is bent with hem edges at *d* and *e*, and the blade B with hem edges at *i* and *j*. The blade is riveted to the head at C with four rivets, soldering along *a b* at the bottom, so that the sheet metal will not slide between the head and blade when in use. A hole is punched at *c*, so that the T-square can be hung up when not in use.

The first pattern to be developed, using the principle shown in Fig. 11 is that of a two-pieced elbow having an angle of 90 degrees, as shown in Fig. 13. In this connection it may be proper to say that in all two-pieced elbows whose angles are 90 degrees the rise of the miter line 1 7 is always equal to the diameter of the pipe at right angles to the arm of the elbow.

In Fig. 14 let A B 1′ 1″ represent a sheet of metal having the required girth and hight to which edges have been allowed for seaming, as shown by *a b* and *c d*, and which has been cut perfectly square on the squaring shears, and from which a two-pieced elbow is to be cut without any waste, the elbow to have an angle of 90 degrees when completed. Knowing the length of the arm on the throat side, as F D in Fig. 13, place this distance as shown from D to F in Fig. 14.

Take the rise of the miter line 1 7 in Fig. 13 and place it in Fig. 14 from F to 7. Bisect F 7 and obtain E, which use as a center and describe the semicircle shown.

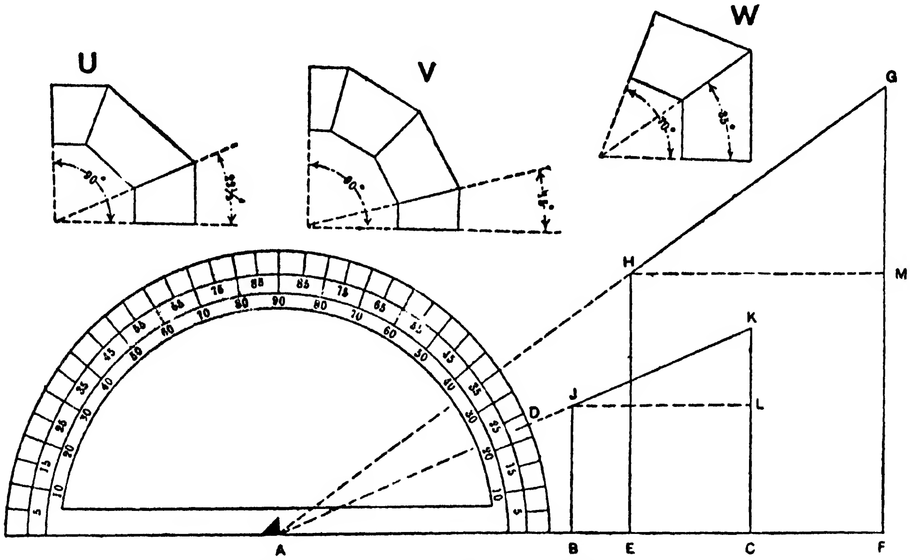


Fig. 15. Finding the Rise of the Miter Line

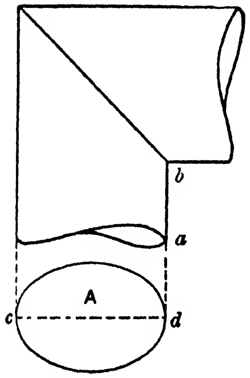


Fig. 16. 90-Degree Elliptical Elbow

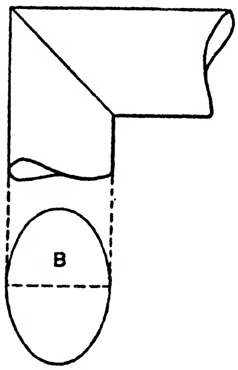


Fig. 17. 90-Degree Elliptical Elbow

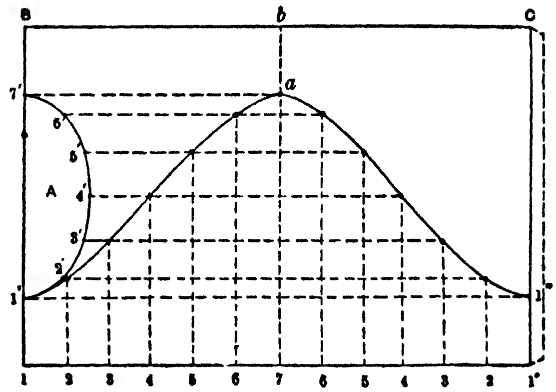


Fig. 18. Pattern for Elliptical Elbow

METHOD OF DEVELOPING PATTERNS OF ELBOW DIRECTLY ON SHEET METAL

Divide this into any convenient number of equal spaces, as shown from 1 to 7. On the line D C, which has already been cut to the required girth, place twice the number of spaces contained in the semicircle E, as shown from 1′ to 7′ 1″.

Now using a metal T-square like that in Fig. 12 in the position shown by X and Y in Fig. 14 draw lines which intersect each other, as shown. A line traced through these intersections, as shown by C H G F D and F G H B A, will be the patterns for the two arms. By measurement J G equals F D; therefore in obtaining the length of the sheet D C is made equal to the girth of the profile that the

pipe is to have, allowing edges for seaming or riveting. And the hight A D is obtained by adding together the length of the arm on the throat side, as F D in Fig. 13, the diameter of the pipe 1 7 and again the distance of F D; or, in other words, the hight of the metal sheet is equal to D F+E + 7 A in Fig. 14. Thus it will be seen no drawings are required, the work being done direct on the metal, with less time than is required to explain it.

In Fig. 16 is shown a two-pieced elbow of 90 degrees, whose section or profile is shown by the ellipse A, for which patterns are required. Cut a piece of metal with the edges perfectly square with each other, whose length, B C in Fig 18, is equal to the girth of the ellipse, A in Fig. 16, and whose hight, 1 B in Fig. 18, is equal to twice the length of the arm on the throat side, *a b* in Fig. 16, plus the diameter, *c d* in the ellipse A.

On 1 B in Fig. 18 set off 1 1′, equal to the throat side of the arm; 1′ 7′ equal to tne diameter of the pipe at right angle to the line of the arm, and 7′ B equal to 1′ 1. Place one-half of the section A, Fig. 16, at A in Fig. 18. With the dividers space A into any number of equal parts, as shown from 1 to 7′, and on 1 1° place twice the number of spaces shown in A. Using the T-square intersect similar lines, as shown. Then 1, 1′, *a*, 1″, 1°, and 1″, *a*, 1′, B, *b*, C are the patterns for the two arms from one piece, allowing laps for joining.

In Fig. 17 is shown a two-pieced 90-degree elbow, whose profile is an ellipse, but placed in the position shown by B, the reverse of A in Fig. 16. In obtaining the patterns for Fig. 17 the same principles are used as shown in Fig. 18.

When patterns are required for elbows containing more than two pieces the rise of the miter line can be obtained without the aid of an elevation of the elbow by using a protractor, as shown in Fig. 15. The rule to be observed is as follows: In all elbows, no matter whether the finished angle is 90 degrees or less, the end pieces count one, while each of the middle pieces count two. Thus in diagram U is shown a three-pieced elbow which has two end pieces and one middle piece, which makes a total of $1+2+1=4$. The number 4 is then the numeral with which to divide the number of degrees which the finished elbow will have. As U has a finished angle of 90 degrees, then $90 \div 4 = 22\frac{1}{2}$, or the number of degrees which the first miter line will involve. In diagram V is shown a four-pieced elbow. Following the above rule we have two end pieces, which equal two and two middle pieces which equal 4; $2+4=6$. Then six is the divisor. As the finished elbow is to have 90 degrees, then $90 \div 6 = 15$, or the degree of the first angle in V. W shows a two-pieced elbow which is to have an angle of 70 degrees when complete. As each end piece counts one, we have $70 \div 2 = 35$, or the miter line.

Assuming that a three-pieced elbow is required whose throat is 30 inches and diameter of pipe 12 inches, then make the distance from the center A of the protractor to the point B equal to 30 inches and B C equal to 12 inches and draw a line from A through the 22½-degree until it meets the vertical lines extended from B and C at J and K respectively. From J, at right angles to J B, draw the line J L, meeting C K at L. L K is then the rise of the miter line.

Knowing the rise of the miter line the pattern for a three-pieced elbow is laid out by the short rule, as follows: Let A B in Fig. 19 represent the girth of the pipe, whose diameter is equal to B C in Fig. 15. Let A 1 or B 1° in Fig. 19 represent the length of the end piece on the throat side, as shown by B J in Fig. 15. Now take the rise of the miter line L K and place it as shown from 1 to 5 in Fig. 19, and with H as center describe the semicircle 1, 3, 5, which divide into one-half the number of spaces contained in the girth A B, as shown. Using the metal T-square erect vertical lines from the divisions on A B of the metal sheet, which intersect by horizontal lines drawn from similar intersections in the semicircle H. A line traced through points thus obtained, as shown by 1 E 1°, will be the desired cut. A B 1° E 1 will be the pattern for the end pieces.

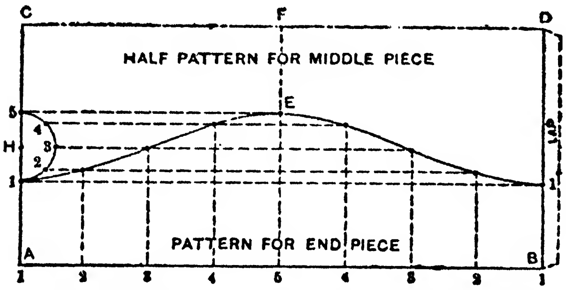


Fig. 19. Pattern for Three-Piece 90-Degree Elbow

Take the distance from B to 1° and place it, as shown, from E to F, and through F parallel to A B draw C D. Then C D 1° E 1 is the half pattern for the middle piece. Trace C A B D opposite the line C D, when the three patterns will be obtained from one piece of metal.

If the pattern was required for an elbow, as shown in diagram W in Fig. 15, whose miter line was equal to 35 degrees, it would only be necessary to draw a line from A through the 35 degrees on the protractor, extending it until it met the lines erected from E, representing the throat, and from F, representing the diameter of the pipe. M G would represent the rise of the miter line and would be used in the same manner as K L was used in H in Fig. 19. No matter what angle the elbow will have when completed, or what size throat or diameter it will contain or its number of pieces, all that is required is to find the rise of the miter line, as for example K L in Fig. 15, and then use it as explained in H in Fig. 19.

PATTERN FOR A SPOUT OR A SHOE

Fig. 20 represents a hanging gutter with spout attached. These spouts can be made of tin, galvanized iron or copper. In putting up angle spouts, as shown A^1, Fig. 20, it is customary to cut a scallop, as shown, so as to make a neat finish. As this is often done by hand, and hardly ever gives accurate results, Fig. 21 has been prepared showing how to obtain the pattern, for when we once have the pattern it can be saved for future use or a dozen spouts made and kept in stock to be used when required. To obtain the pattern of the scallop cut, no matter what size the pipe is, proceed as follows: Let A, Fig, 21, represent the plan of pipe and B the elevation. Care should be taken to draw the scallop in its correct position in elevation, as shown. Divide the plan A, Fig. 21, into an equal number of parts, as shown by the small figures 1, 2, 3, 4, etc., from which drop perpendicular lines until they cut the scallop

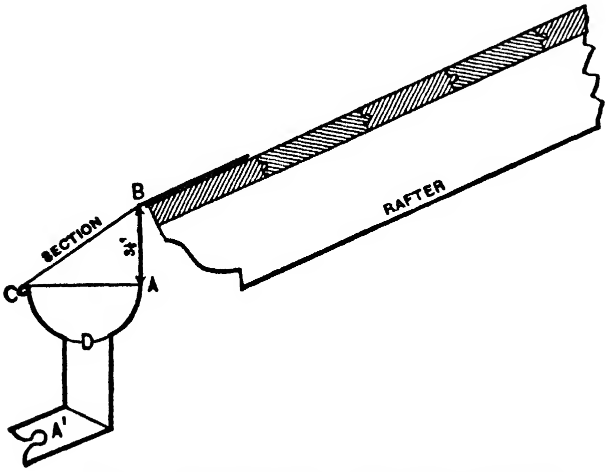


Fig. 20. Hanging Gutter with Spout Attached

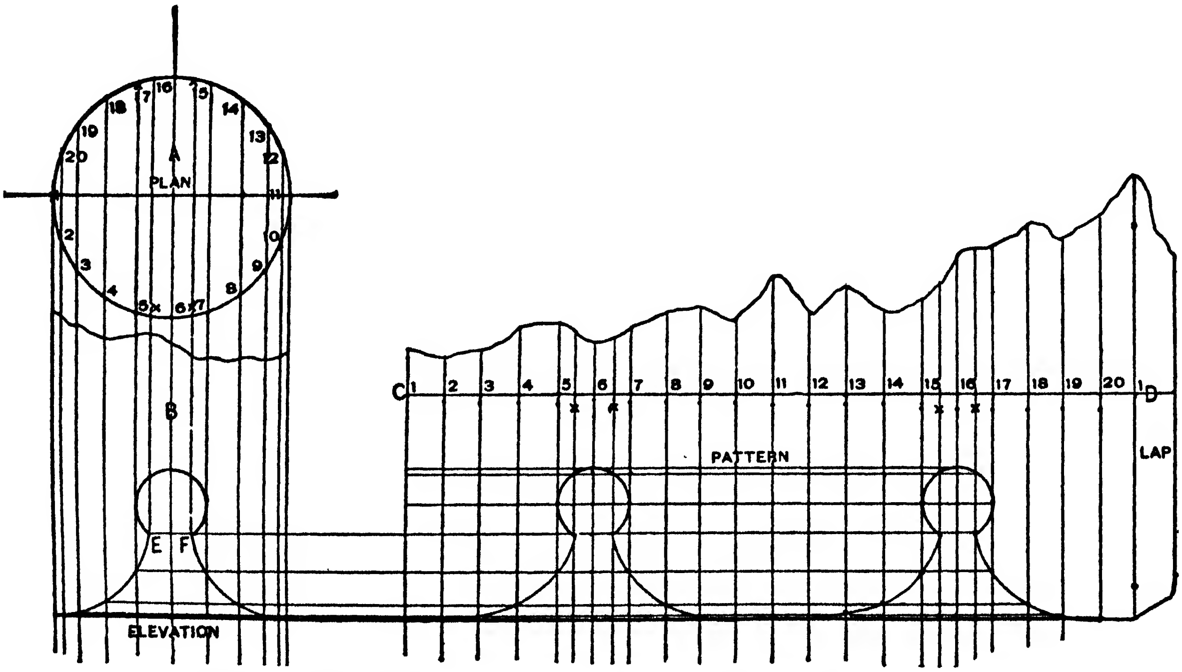


Fig. 21. Plan, Elevation and Pattern for Mouth of Spout Shown in Fig. 20

line, as shown in elevation. At right angles to the perpendicular lines or lines of the pipe draw the stretchout of the plan A, Fig. 21, as shown by C D, the small figures on the stretchout corresponding in number to those on the plan. At right angles to the stretchout line C D draw lines indefinitely from the small figures, as shown, which intersect with lines of corresponding numbers drawn at right angles to the lines of the pipe from the intersections on the scallop line, as shown. Referring to the elevation, Fig. 21, it will be seen that we have two points—namely, E and F—which we carry upward, as shown by the dotted lines, until they cut the plan, as shown by X X X X. We now transfer the extra points X X X X of plan to the stretchout, as shown.

At right angles to the stretchout line C D draw lines from X X X X, which intersect with lines drawn at right angles to the lines of the pipe from the points E and F, Fig. 21. A line traced through these intersections will be the required pattern for the scalloped mouth of spout, as shown in Fig. 20. A lap is allowed for riveting, as shown.

PATTERN FOR RAIN WATER CUT OFF

In Fig. 23 first draw the front elevation, shown by A D J M, with the miter line *l* G. The pipe A B L M extends into the cut off, as indicated by B *i j* L. This is done to allow the pipe to meet the scoop or cut off *c d e*. The pattern for the inlet is a piece of metal whose hight is equal to A *i* and length equal to the circumference of the profile N, to which laps are allowed for seaming.

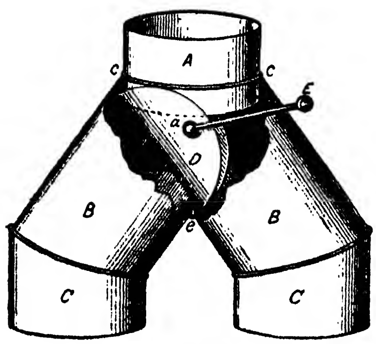


Fig. 22

Directly below one of the outlets, as I J, draw the profile O P R S, which divide as shown. From these points erect lines intersecting H K. From these intersections, parallel to G H, draw lines intersecting the miter or joint line G *l* L. From the point *l*, parallel to L K, draw a line intersecting H K at *l′*, from which drop a line cutting the profile at *l″* and *l″*, these points being required when developing the pattern.

For the pattern for the middle section draw, at right angles to L K, the line T U, upon which place the stretchout of O P R S. At right angles to T U draw the usual measuring lines, which intersect with the lines drawn at right angles to L K, from the various intersections on H K and G *l* L. A line

traced through the points thus obtained, as shown by V W X Y Z, will be the pattern for H G *l* L K in elevation.

For the pattern for H I J K take the distance K J and place it in the pattern on the lines X W and Z V, extended, as shown, by W J^1 and V J^2. Draw a line from J^1 J^2. Then will W J^1 J^2 V be the desired pattern.

The next step is to obtain the pattern for the scoop, or cut off, *c d e*, by means of which the water is thrown into the right or left outlet. Parallel to G H draw *d e*, making the distance between *d* and G about ⅛ inch, to give a little play. From *e*, ⅛ inch from C B, draw the horizontal line *e c*. Bisect *e d*, obtaining *h*, from which, at right angles to *e d*, draw *h c*, intersecting the joint from line G *l* at *f* and *e c* at *c*. From *c* drop the line *c d*, intersecting *e d* at *d*. The inlet pipe should

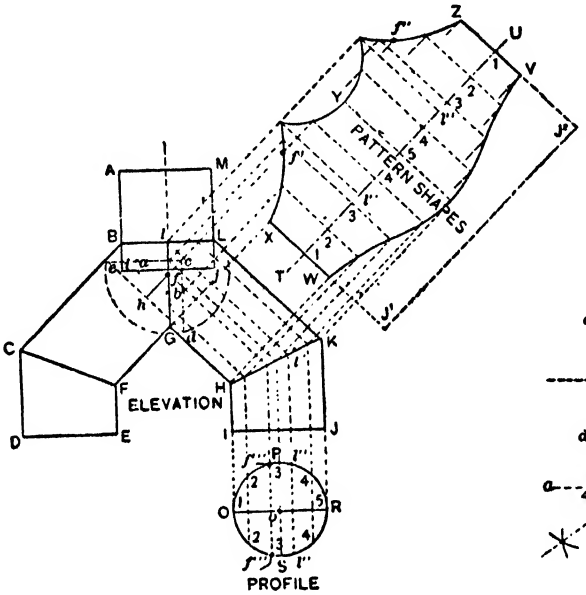


Fig. 23. Elevations and Patterns

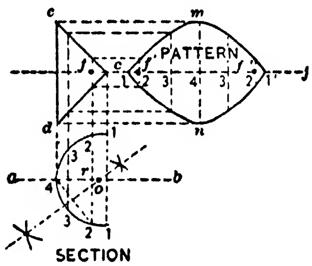


Fig. 24. Pattern of Cut Off

be allowed to extend inside the cut off, so as to have a distance of "*a*," or 1 inch. The distance *b* should also be about 1 inch. As *f* represents the center of the pivot, then from this point draw a line at right angles to L K, intersecting the miter cut in the pattern X Y Z at *f′* and *f″*, which gives the location of the holes to be punched for the pivots.

For the pattern for the scoop take a tracing of *c d e* with the center *f* and place it as shown by similar letters in Fig. 24. Through the center of the pivot *f* draw *f j*, parallel to which draw *a b*. From *e*, *f* and *c* drop lines intersecting *a b* at 4, *r* and *o*. From the pivot *f* in elevation in Fig. 23 draw a line parallel to L K, intersecting H K, from which drop a line intersecting O P R S at *f‴* and *f‴*. Now take the distance from the center line O P, as *o* to *f″*, and place it in Fig 24, from *r* to 2, on

either side, on the vertical line dropped from *f*. Draw a line from 4 to 2. Bisect 4 2, and from the point of bisection erect a perpendicular line, intersecting *a b* at *o*. Then, with *o* as center and *o* 2 as radius, draw the arc 1, 4, 1, intersecting the line drawn from *c* at 1 and 1. Space the arc into spaces, as shown, from 1 to 4 to 1, from which erect lines intersecting *e c d*, as shown. Now take a stretchout of 1, 4, 1 and place it on *c j*, as shown by similar figures, and through which draw the usual measuring lines, which intersect by lines drawn from similar intersections *e c d* parallel to *c j*. Trace a line through the points thus obtained. Then will 1 *m* 1′ *n* be the desired pattern. As the point *f* comes in line with 2 and 2 in the section, then, where the center line *c j* passes through the lines 2 and 2 in the pattern, locate *f′* and *f″*, the centers through which the pivots will pass.

The construction of the rain water cut off is as follows: The two elbows B C and B C, in Fig. 22, are first made and are then seamed together at *e*. The scoop D is then placed in position, passing the handle E through the pivot hole *a* on both sides. The handle E is made from 3-16 inch galvanized wire. Now, knowing the distance that the main pipe A is to extend on the inside, put a bead around the pipe, as shown at *c c*, and press it into the junction of the two elbows, and solder around the entire bead.

TRUE ANGLE IN CONDUCTOR PIPE

Fig. 25 illustrates a leader turning the square corner of a building; both branches making angle of 45 degrees with the vertical. Pattern will be an elbow of the angle of Fig. 29 developed in the usual manner.

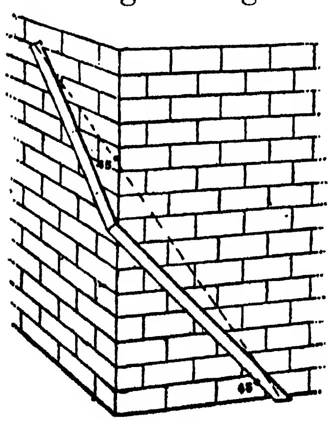


Fig. 25

Draw the two elevations of the pipe as shown in Figs. 26 and 27, the line A B C representing the center line of the pipe in both cases. Next lay off, as in Fig. 28, the distance B′ C′ equal to C D of Fig. 26; at the point B′ lay off at right angles to B′ C′ the line B′ A′ equal to A E of Fig. 27. Then the line A′ C′ will represent the horizontal projection of the imaginary line A C. At the point A′ erect the perpendicular A′ O equal to D A or C E. Then O C′ will be the true length of the imaginary line A C. Construct the triangle A″ B″ C″ with A″ B″ equal to A B

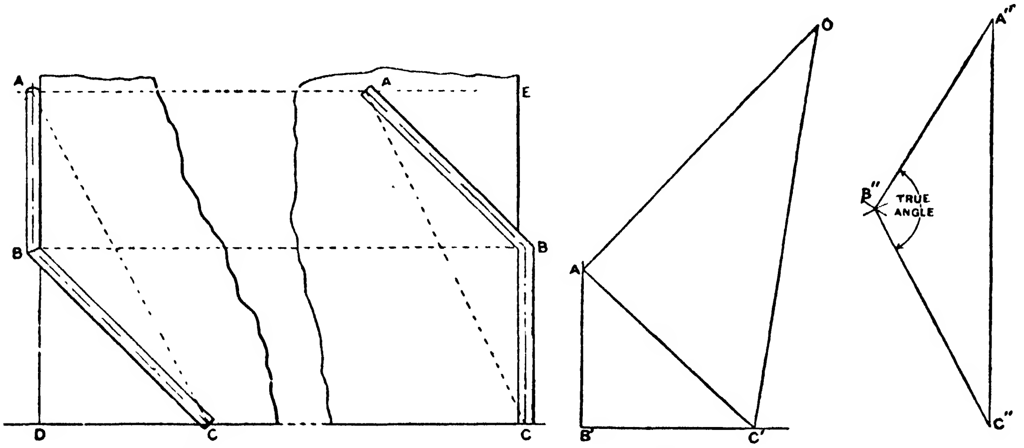


Fig. 26 Fig. 27 Fig. 28 Fig. 29

TRUE ANGLE IN CONDUCTOR PIPE

of Fig. 27, B″ C″ equal to B C, Fig. 26, and A″ C″ equal to O C′ Fig. 28. The angle A″ B″ C″, Fig. 29, will be the required angle.

PATTERNS FOR OCTAGON CONDUCTOR

For obtaining the patterns for an octagon conductor elbow and tee joint for connecting an octagon conductor with a circular trough. In Fig. 30, let A B C D E F represent the elevation of elbow, and G H I J the profile of same. The angle B C D can be made as desired, the pattern being obtained in a similar manner. Draw the profile in line with the elevation, and from the various points indicated by the small figures, carry lines parallel with C D cutting the miter line C F. On C D extended, as K L, lay off a stretchout of profile, and from the point thus obtained draw the usual measuring lines. Place the blade of the T-square parallel with the stretchout line K L, and, bringing it successively against the points in C F, cut corresponding measuring lines. Then straight lines connecting the points thus obtained, as shown by K L O N M, will give the desired pattern.

In the elevation, Fig. 31, let A Z B represent the circular trough struck from the center X, and let C D E F represent the octagon conductor, as shown in the profile by G H I J. From the points in the profile, carry lines through the elevation of conductor cutting A Z B, as shown. As the sides of conductor similar to 2 3 or 4 5 intersect the conductor obliquely, the radius used for striking the shape of trough could not be used for describing these parts of the pattern. Therefore

divide 2 3 or 4 5 into any convenient number of equal parts, as shown by *a b* and *c d*, and from the points thus obtained carry lines cutting A Z B, as shown. Extend E D, as shown by K L, upon which lay off a stretchout of the profile, and from the

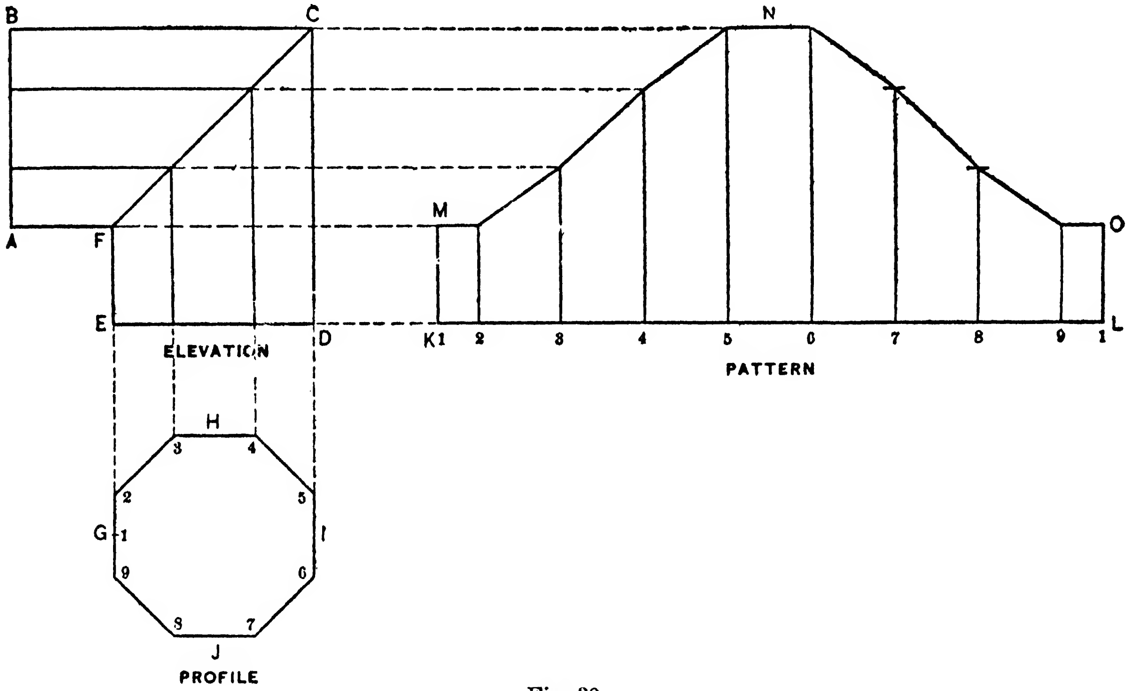


Fig. 30

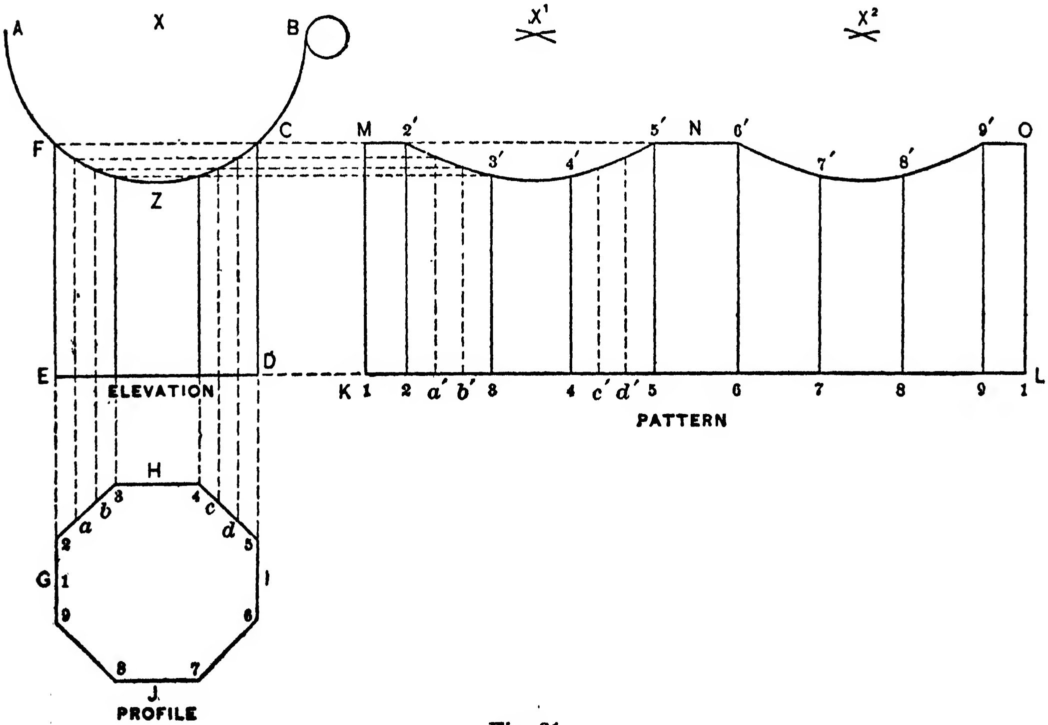


Fig. 31

points thus obtained in same erect the usual perpendicular measuring lines. Place the T-square parallel to the stretchout line and, bringing it successively against the points in A Z B, cut corresponding measuring lines. Thus M 2′, 5′ 6′ and 9′ 0 of pattern are parallel with the stretchout line, while 2′ 3′ and 4′ 5′ are derived from the points in A Z B of elevation; 6′ 7′ and 8′ 9′ of pattern can be obtained in the same manner as were 2′ 3′ and 4′ 5′, or the shape 2′ 3′ can be used for marking 6′ 7′ and 8′ 9′. The part of 3′ 4′ of pattern can be obtained by setting the compasses to the radius X A, used in describing A Z B of elevation, and with points 3′ and 4′ as centers strike arcs in the direction of X′. With the same radius and with X′ as center strike the arc 3′ 4′; 7′ 8′ of pattern can also be obtained in a similar manner, from X^1 as center.

A HOOK COVERING TO CONCEAL HANGERS

In Fig. 32 is shown a perspective view of a square pipe, or leader, fastened against a wall by means of a hook. If the hook was left in this position it would make a bad appearance; to overcome which a galvanized sheet metal covering is

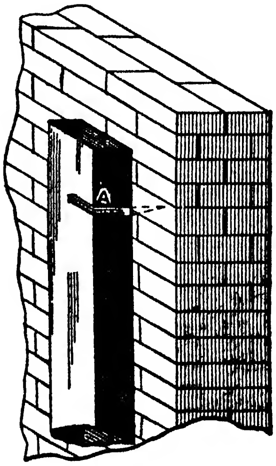


Fig. 32. Square Pipe Fastened Against a Wall with Hook Shown in Fig. 88

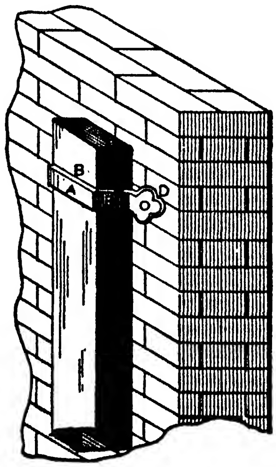


Fig. 33. Method of Covering the Hook with Metal

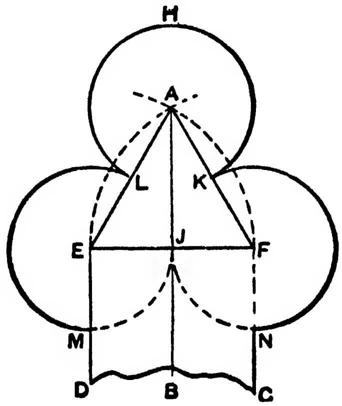


Fig. 34. Geometrical Figure

placed over the hook, using galvanized iron for a galvanized iron leader and copper covering for a copper leader. The appearance is shown at A in Fig. 33. The covering A in Fig. 33 is slipped over the hook shown at A in Fig. 32 and soldered

along the top of the covering and against the leader, as shown at B and C, Fig. 33, thus making a clean and neat appearance.

In Fig. 34 is shown the method of obtaining the geometrical figure or leaf for the sheet metal covering as indicated at D, Fig. 33. To obtain the leaf proceed as follows: Draw any perpendicular line, as A B, Fig. 34, upon either side of which place the half distance of the width the covering A, Fig. 33, is to have, as shown by the line E F, drawn at right angles to A B in Fig. 34. Now upon this line construct an equilateral triangle, or a triangle having three sides equal. With F, Fig. 34, as center and F E as radius strike an arc, as shown, from E to A; then with E as center and E F as radius strike another arc, intersecting the first one at A. Now draw the line from A to E and from A to F; then will A E F represent the triangle desired. It will be noticed that the line A B, Fig. 34, bisects the line at E F at J. Now with F as the center point for the compass and with F J as radius strike an arc, cutting the line A F at K; then with A as center and with the same radius strike another arc, cutting the line A E at L. Then again with E as center and using the same radius strike an arc from the point L, meeting the point J on the line E F. Now at right angles to E F, or parallel to A B, drop lines as shown from E to D and F to C. The distance N to C, or M to D, can be made to the width desired, as indicated at A, front view, Fig. 35. Then will C N H M D represent the leaf desired. It should be understood that the width of the covering shown from E to F in Fig. 34 gives the basis for obtaining the center point from which to strike the arcs, and therefore makes the leaf in proportion to the width of the covering.

In Fig. 35 are shown the front, plan and sectional views of a hook covering, including the patterns. Let Z in the plan represent the size of the leader used, lying against the wall, as shown, around which is placed the plan view of the covering. The width of the front view of covering shown from B to C should be made from 1 to 1½ inches, according to the size of the pipe used; while the width shown from 1 to 2 or 3 to 4 in plan, or what is the same, the width from 1 to 2 or 3 to 4 in the section, should be made a little wider than the width of the hooks so that the covering will slip over easily.

After having the front and plan views drawn in their proper position to each other, as shown by the dotted lines, draw a section of the covering in the plan, as shown at T, from which to obtain the stretchout. S, S′, S′, S represent the four miter lines in plan. To obtain the patterns for the coverings proceed as follows: At right angles to the line S′ S′ in plan draw the stretchout C D, as shown, upon which place the stretchout of the section T in plan, as shown by the small figures

1, 2, 3 and 4, corresponding in number to those on the section. Now at right angles to the stretchout C D draw lines indefinitely through the small figures, as shown, which intersect with lines of corresponding numbers drawn from the miter lines S′ and S′, parallel to C D. A line traced through these intersections will be the required pattern for the front of the covering shown at A, Fig. 33. For the pattern of the side of the covering, shown at E, Fig. 33, proceed as follows: Parallel with the line S′ S′, Fig. 35, draw the stretchout E F, upon which place the stretchout of the section T of the plan view, as shown by the small figures 1, 2, 3 and 4 on the stretchout line E F. At right angles to the stretchout draw lines indefinitely through the small numbers, as shown, which intersect with lines drawn at right angles to the line S′ S, from the miter lines S′ and S. A line drawn through these intersections will be the required pattern for the two sides of the covering, as shown at E in Fig. 33. The pattern for the front and sides of the covering can be made in one piece if desired. In Fig. 36 let A represent a duplicate of the pattern of the front, as shown by M N O J, Fig. 35, and B B, in Fig. 36, represent duplicates of the pattern of the side shown by X E Y F, Fig. 35. It will be noticed that X of the pattern for the side in Fig. 35 joins X′ and X′ on either side of the pattern for the front in Fig. 36, the joining being shown at X^2 X^2, Fig. 36. Then will B A B, Fig. 36, be the desired pattern for the front and two sides of the covering. Laps are allowed as shown by the dotted lines in Fig. 36.

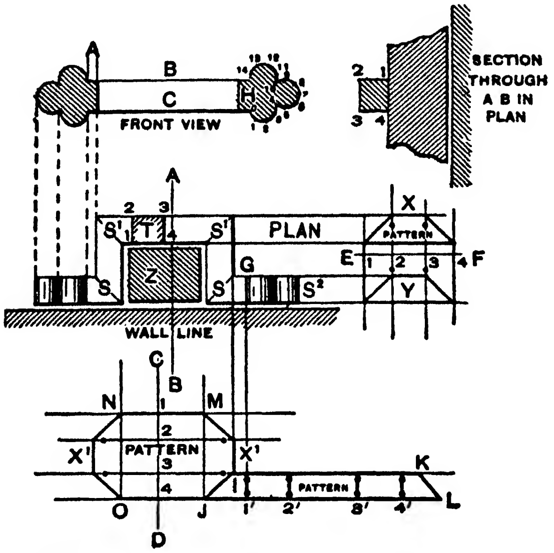


Fig. 35. Front, Plan and Sectional Views of Hook Covering; also the Patterns

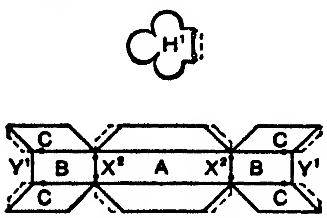


Fig. 36. Pattern in One Piece

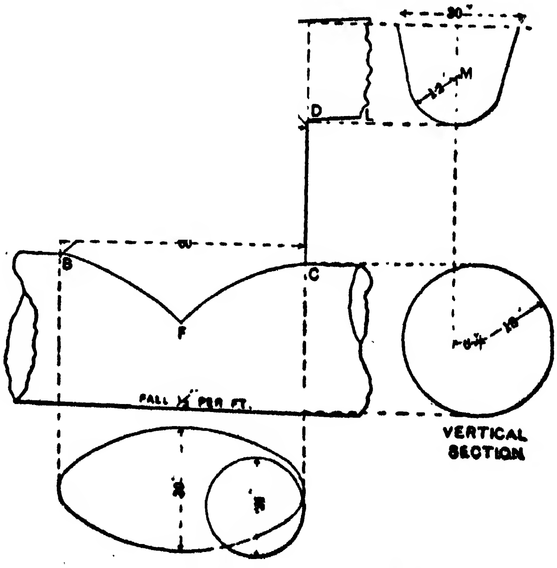
For the pattern of the strip which bounds the leaf H, front view, Fig. 35, proceed as follows: At right angles to C D of the pattern, Fig. 35, draw the lines 3 and 4 indefinitely to the right, as shown by 3 K and 4 L. It should be understood that the width 3 4 of the pattern on the line C D, Fig. 35, is the same as the width 3 4 of the section, and is the width of the strip which bounds the figure H in front view, as shown by S S^2 in plan view. From the bend G in plan view, which corresponds to the angle 1 and 14 of the leaf H in front view, drop a perpendicular line cutting the lines I K and J L, as shown at 1′

of the pattern. Now space the leaf H, front view, Fig. 35, into an equal number of parts, as shown by the small figures from 0 to 14; transfer the space with the dividers from 0 to 4, front view, on the lines I K and J L, from 1′ to 2′. Now transfer the space from 4 to 10, front view, to the pattern, as shown from 2′ to 3′; then again transfer the spaces from 10 to 14, front view, to the pattern, as shown from 3′ to 4′. Now place a duplicate of the miter 1′ J I, Fig. 35, as shown at 4′, L and K, which completes the pattern. Then will I J L K be the pattern for the strip bounding the leaf H, front view, Fig. 35. The miter I J will be cut away from the pattern of the front, as shown. The leaf H′, shown in Fig. 36, is a duplicate of the leaf H, front view, Fig. 35. A lap is allowed at H′, Fig. 36, which is bent at right angles and soldered to Y′ Y′, Fig. 36.

If a bar folder is at hand, the pattern shown in Fig. 36 could be bent upon the two lines C C and C C, after which the cross bends could be bent by hand, as shown by X^2 X^2, Fig. 36, and soldered to their required angles. If a folder is not at hand the pattern B A B, including the leaf H′, Fig. 36, and the strip for the leaf shown by I J L K, in Fig. 35, could be bent upon the hatchet stake.

PATTERN FOR A SHOE TO CONNECT A GUTTER WITH A CONDUCTOR PIPE

The problem is a "shoe collar" to connect a 24-inch gutter with a 36-inch conductor pipe, the upper opening of the same to be 24 inches in diameter, while the opening in the base is to be elliptical and 30×60 inches. The "shoe," as we term it for convenience, is a very irregularly shaped piece, inasmuch as its top, as shown by the plan, Fig. 37, is not centered on either axis of the elliptical base. Neither is the axis of the base concentric with that of the conductor pipe; besides which both the gutter and the pipe are carried at a slight inclination or rake. The pattern for such a piece must, of course, be developed by triangulation.



Plan of Miter Lines. Fig. 37

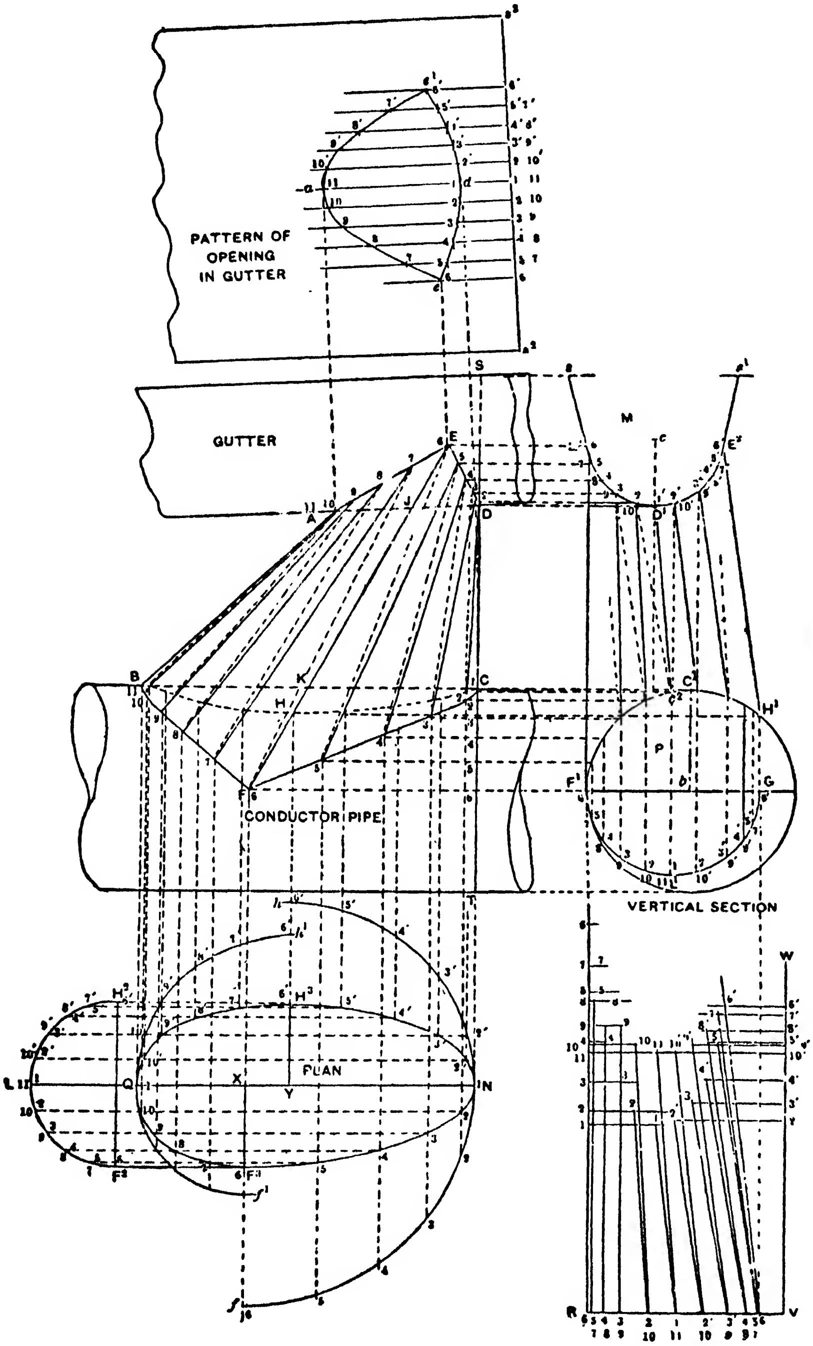
The great difficulty at the outset will be to determine or establish the lines of

intersection between the shoe and the pipes above and below. These lines of intersection will, of course, represent the openings in the two pipes and will become the upper and lower bases of the shoe. In the matter of determining these lines the draftsman is thrown largely upon his own judgment and general knowledge of intersections, inasmuch as the plan of miter lines shown in Fig. 37 is not very explicit. It must be taken into consideration that the shape or horizontal section of the shoe when finished will depend entirely upon the location of these miter lines. It is no doubt the intention to have the shoe cylindrical, or nearly so, at the top—that is, on a straight line from A to D—and elliptical at the bottom from B to C; but if we are to interpret the 24-inch circle of the plan to mean literally a section through points A, E and D, then the result will be quite different. Suppose, for instance, that a round pipe of the same diameter as the top of the shoe (24 inches) be substituted for the shoe. If it were placed in a vertical position, as though C D were one side of it, it would intersect the gutter as shown by the line A E D, the point E being on the axis of both the pipe and the cylindrical part of the gutter; but if it were inclined to the angle shown by A B, then the position of the point E would fall considerably to the right of its present position, which will be discovered by drawing a line parallel to and 12 inches away from A B and extending it to meet the axis of the gutter. In order that the upper section of the shoe shall remain circular, the position of the point E must therefore be somewhere between its present position in Fig. 37 and where it would be according to the latter supposition.

As a further help in determining the proper position of the miter lines, it will be well to consider for a moment what the result would be if they were to be accepted as drawn both at the top and the bottom of the shoe, and the pattern developed therefrom. A line drawn from E to F represents the position of what may be termed an axial plane, or the plane of greatest width measured from front to back, which plane, as will be seen by reference to Fig. 37, passes much nearer to A than to D, thus compressing or flattening, as it were, that part of the sectional outline toward A and elongating that part toward D and producing a marked distortion of the circle.

The same state of affairs exists at the bottom of the shoe, though in a less degree, because of the increased length of the base as compared with its width; but the axial plane, if the point F is to remain fixed, will still pass nearer to C than to B.

To this end therefore, a carefully made elevation and sectional view should be drawn, as shown in Fig. 38, in which corresponding parts are lettered the same as 37. The view at the right represents a section on the line S T of the



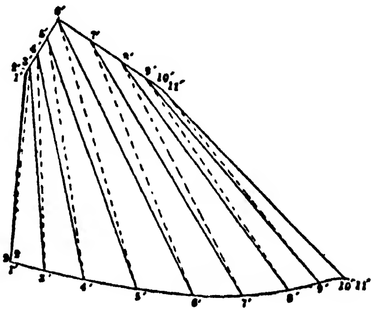


Fig. 89. Triangulation of Rear Side of Shoe

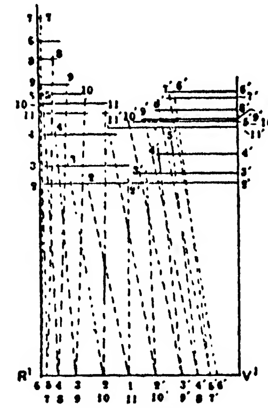


Fig. 88. Method of Obtaining Lines of Intersection Between the Shoe and the Pipes Above and Below, and Triangulation of the Shoe

Diagram Showing Lengths of Solid Lines of Elevations

Fig. 40. Diagram Showing True Lengths of Dotted Lines in Elevations

elevation. The points D^1 and C^1 are obtained by horizontal projections from D and C of the elevation, the point C^1 being set the required distance (6 inches) to the right of a plumb line dropped from D^1, as in Fig. 37. Now set off from F^1 on the horizontal diameter of the conductor pipe the width of the shoe at the base (30 inches) as obtained from Fig. 37 and as shown by F^1 G of Fig. 38, and at G erect a line, cutting the circumference at H^1. Draw F^1 E^1, representing the face line of the shoe, and H^1 E^2, showing the back line. It will be noted that the points E^1 and E^2, being 24 inches apart, as required, will intersect the gutter M slightly below a level line drawn through the center *c* because of the tapering sides of the gutter. Next bisect a line from A to D, as shown at J, and one from B to C, obtaining K, and through these points draw a line, extending it above to intersect a horizontal line from E^1, as shown at E, and below to intersect a line from F^1, as shown at F. The line E F will then represent the position of the axial plane above referred to. Lines drawn from A to E and from E to D will then represent the planes of intersection between the gutter and the shoe and form the upper base of the shoe in such a manner as to produce a section at A D, which is a very close approximation to a perfect circle.

Since the plan of the shoe at its base is not concentric with the conductor pipe, as previously shown, no lines similar to those at the top can be drawn, because the intersections do not occur upon a plane surface, as will be seen. Such a working plan must therefore be constructed as will produce the desired elliptical section at B C, which may be done in the following manner: First draw any horizontal line, as L N, at a convenient distance below the elevation and from points B, F and C drop lines, cutting the same as shown at Q, X and N. Now from H^1 of the sectional view project a line horizontally into the elevation, cutting the line E F at H, and from H drop a line, cutting L N at Y. Upon lines drawn from X and Y, at right angles to L N, set off half the desired width of the base of the shoe, as shown in Fig. 37—that is, one-half of 30 inches—locating the points F^3 and H^3. Then Y Q and Y N will each be one-half the major axis of two ellipses, of which Y H^3 is half the minor axis, and X Q and X N will each be half the major axis of two other ellipses, of which X F^3 is half the minor axis. The plan will thus consist of four quarter ellipses so placed together that the axial plane, represented by F E of the elevation, will be coincident with X F^3 of the plan at F of the elevation and with Y H^3 of the plan at H of the elevation, and when the point K is reached will be exactly midway between the two ends, thus forming at that point a symmetrical and nearly perfect ellipse at B C.

The most available method of drawing the quarter ellipses necessary to complete

the plan is that frequently employed of first drawing two circles whose diameters are respectively equal to the major and minor axis of the desired ellipse, and then dividing both circles into the same number of equal spaces and making intersections from corresponding points in each. In the present case four quarter circles will be therefore required whose radii will be respectively equal to the four half major axis, one pair of which may be drawn from Y of the plan, with Y Q and Y N as radii, as shown by Q h^1 and N h, while the other pair may be drawn from X as center, as shown by Q f^1 and N f. A half circle whose diameter is equal to the required minor axis of the plan may be described from any convenient point on L N as center, its diameter being drawn parallel to X F^3 or Y H^3, as shown by F^2 H^2. Each of the six quarter circles may now be divided into the same number of equal parts, numbered correspondingly, as shown by the small figures, remembering that the semicircle H^2 L F^2 being made to answer for a full circle, each point therein must carry two numbers, each quarter circle composing it being used in developing two quarters of the plan, all of which will be clear from an inspection of the plan. Horizontal lines drawn from points 1 to 6 of L H^2 are intersected with vertical lines dropped from corresponding points of the quarter circle N h, and those from 6 to 11 of L H^2 are intersected with lines dropped from the quarter circle Q h^1, while lines from the points in L F^2 are intersected in the same manner with lines from the quarter circles N f and Q f^1. Lines traced through the points of intersection, as shown by Q H^3 N F^3, will complete the outline of the plan.

So far as the usefulness of this plan is concerned, it is immaterial whether the line of its major axis L N be drawn horizontally or parallel to B C, the slant of the pipe, since its only purpose is to produce an opening in the top of the pipe to serve as the lower base of the shoe. If the pipe were very oblique it would then be better to draw L N parallel to B C. In that case the projections now made vertically would then be made at right angles to the lines of the pipe. Since the principal points of the plan have been obtained by vertical projections from the elevation, so the line of the opening in the elevation will have to be completed by vertical projections from the plan, intersected with lines projected from points on the section of the pipe which shall correspond with those of the plan. It should be noted, first, that the section at the right in Fig. 38 is a vertical section on the line S T of the elevation and is therefore not at right angles to the lines of either the gutter or the conductor pipe, but the difference in this case between the sections S D and C T and right sections of those pipes is so slight that it need not be considered. In the subsequent operations, however, of making horizontal projections from the several points in the two profiles M and P to the elevation, lines must first be carried

in every case horizontally to the line S T, thence parallel to the respective rakes of the two pipes to their required intersections, all as shown.

To proceed now with the development of the opening F B C, points corresponding to those of the plan must be located upon the profile between F^1 and H^1. This can be most conveniently accomplished by describing upon F^1 G as a diameter a duplicate of the semicircle F^2 L H^2, as shown by F^1 L^1 G, and dividing it into the same number of equal spaces. Lines may now be projected from the several points in F^1 L^1 G to the arc F^1 C^1 H^1, and from the points thus obtained on F^1 H^1 they are carried horizontally to intersect with vertical lines of corresponding numbers from the points of the plan. A line traced through the points of intersection, as shown by F B H C, will then show the exact elevation of the desired opening.

It may be remarked that the method of developing this opening could not be well or clearly explained without first having drawn the ellipses Q N of the plan from which it is logically derived, but since each elliptical arc is itself obtained by the equal division of quarter circles, whose diameters are respectively equal to the major and minor diameters of the required ellipses, the points of intersection just obtained in the elevation may be obtained at once from the divisions of the several quarter circles without completing the plan at all, thus shortening the operation considerably. To obtain it by this method, then, first obtain the points Q, X, Y and N of the plan, and from X and Y as centers draw the four quarter circles as before explained, upon the assumption that they are the arcs necessary to produce the required ellipses of the plan; then draw the semicircle F^1 L^1 G, omitting its duplicate F^2 L H^1, and, having divided each of the quarter circles of both the plan and the section into spaces as before, proceed with the intersections in the elevation, working from the points in the four quarter circles of the plan instead of, as in the former case, from the points in the elliptical curve.

In order to obtain a set of points in the upper base of the shoe for the purposes of triangulation, divide the semicircle E^1 D^1 E^2 into the same number of equal spaces as F^1 L^1 G, as shown, and from the points thus obtained project lines horizontally into the elevation by the method above mentioned, between the lines E D and A E, and number them to correspond with those just obtained in the lower base; after which lines of similar number in the upper and the lower bases may be connected by solid lines, while points in the lower base may also be connected with those of the next higher number in upper base by dotted lines, all as shown. In order to avoid a confusion of lines the triangulation of the rear half of the shoe is shown in Fig. 39, in which the same figures bearing primes are used as in the forward half. As a number of the lines near D C are almost coincident, the arrange-

ment of the triangles of that portion is shown more clearly in the sectional view, which includes an end elevation of the shoe.

Since now the line E F is the only portion in the surface of the shoe which lies in a vertical plane (as shown by E^1 F^1 of the section), all other lines are more or less oblique; certain diagrams must therefore be constructed upon which the true lengths of the several solid and dotted lines just drawn can be measured. Such a diagram for measuring the solid lines is shown immediately below the section and is most easily obtained by projections therefrom in the following manner: From F^1 of the section draw a vertical line, F^1 R, cutting the horizontal line R V drawn at any convenient distance below the vertical section. Upon R F^1 set off from R the lengths of the several solid lines in the front elevation of the shoe, as shown by the small figures 1 to 11, and to avoid confusion of these lines set off upon any other vertical line, as V W, the length of the several solid lines of the rear elevation, Fig. 39, as shown by V 2′ to V 10′, inclusive. From each of the points in R F^1 and V W draw horizontal lines coming below the vertical section and intersect each with a line dropped vertically from points of corresponding number in the profile M; and from points in the half circle F^1 L^1 G drop lines cutting R V, numbering each to correspond, all as shown. Now connect points in R V with those of corresponding number in the upper intersections by solid lines, as shown. Their lengths will then represent the true lengths of the corresponding lines of the two elevations, Figs. 38 and 39.

A similar diagram giving the true lengths of the dotted lines of the two elevations is shown in Fig. 40, which may be constructed in the same manner as that just described. Set off on the perpendicular at R^1 the lengths of the several dotted lines in the front elevation and on the one at V^1 the lengths of those of the rear elevation, giving to the points thus obtained the figures corresponding to those at the upper ends of the lines in the elevations. The intersections on the horizontal lines in the upper part of the diagram may be obtained in the same manner as those of the first diagram, provided it is drawn, as it should be, either directly above or below the vertical section, while the divisions of R^1 V^1 are exactly the same as those of R V. Dotted lines are drawn, as in the elevations, to connect points at the bottom with those of the next higher number at the top.

Before the operations of developing the pattern can be begun it will be necessary to first determine the true distances between points of consecutive number in both of the bases. Those of the upper base can, if desirable, be obtained by the development of the sections on the lines A E and E D before referred to; but since the shapes of the openings in the pipes will be required to complete the work, the

preferable method will be to first develop the patterns for the openings in both the pipes. That of the gutter is most conveniently obtained above the elevation. The stretchout of the profile M is set off on any line, as s^2 s^3, drawn at right angles to A D, embodying the points as previously obtained between E^1 and E^2, as shown by the small figures in s^2 s^3. The measuring lines from these points are then intersected by lines from points of corresponding numbers in the miter lines A E and E D, projected at right angles to A D, as indicated. A line traced through the points of intersection, as shown by *a*, *e*, *d*, e^1, will give the shape of the opening, and the spaces between these points must necessarily be equal respectively to those in the upper edge of the pattern. The development of the opening in the top of the conductor pipe below is obtained in exactly the same manner, all as shown in Fig. 41, the points in the stretchout line *g t* being obtained from the points between F^1 and H^1 of the profile P of Fig. 38. The spaces between the points in the line of the opening *f b h c* will then be the correct distances to employ in the development of the lower line of the pattern.

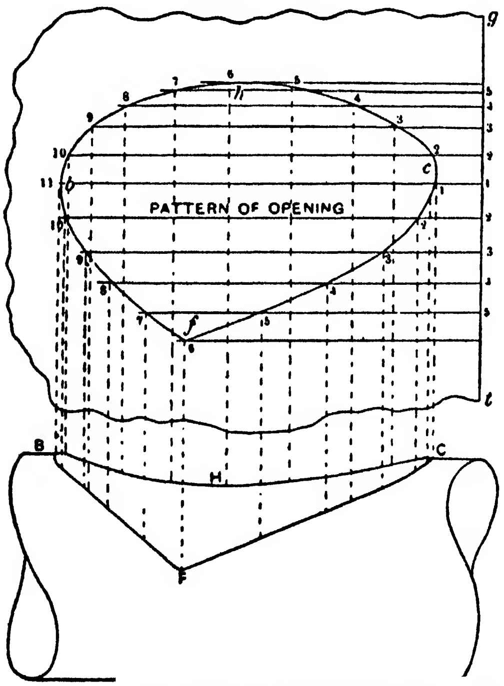


Fig. 41. Method of Obtaining the Shape of Opening in Top of Conductor Pipe

The development of the pattern is shown in Fig. 42, in which the line D C corresponds with D C of the elevation or D^1 C^2 of the vertical section in Fig. 38, that part of the pattern for the forward side of the shoe being shown at the left, while that of the rear side is shown at the right of D C. Upon D C first set off the distance 1 1 equal to 1 1 of the diagram in Fig. 38. Now from point 1 near the bottom of the line as center, with a radius equal to the length of line 1 2 of the diagram, Fig. 40, describe a short arc at the left of 1 at the top of the lines which intersect with a short arc struck from the latter point 1, with a radius equal to the distance 1 2 of the line *d e* of the pattern of opening in Fig. 38, thus establishing the point 2 in the upper line of the pattern. From this point as center, with a radius equal to 2 2 of the diagram in Fig. 38, strike a small arc at the left of 1 at the bottom of the pattern, which intersect with any other arc struck from the last mentioned 1 as center, with a radius equal to 1 2 of the pattern of the lower opening in Fig. 41, thus establishing point 2 in the lower line of the pattern. Continue this operation,

using consecutively the lengths of the several dotted lines in the diagram, Fig. 40, as radii in measuring from the last obtained points in the bottom edge of the pattern, in connection with the distances in the lower half of the pattern of the opening in the gutter, Fig. 38, using them in numerical order in developing the upper out-

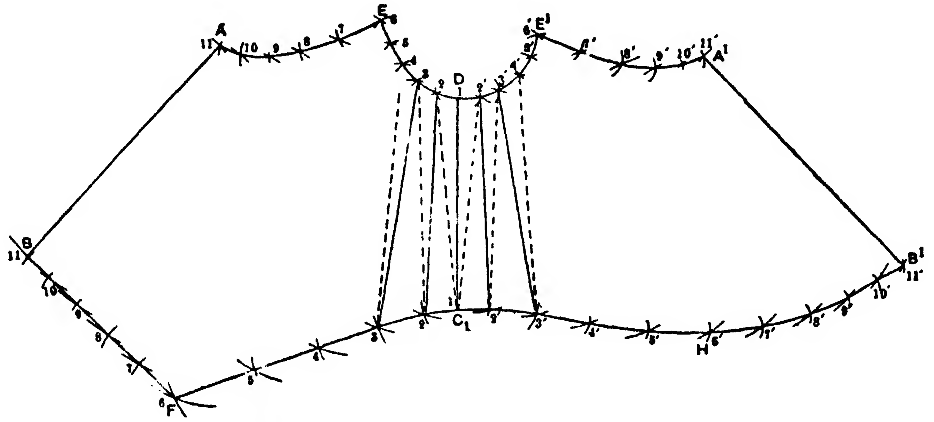


Fig. 42. Development of Pattern of Shoe

line of the pattern of the forward half of shoe, while the lengths of the several solid lines in the diagram in Fig. 38 are used in combination with distances between the points in the lower half of the outline of the opening in Fig. 41 to develop the lower outline of the pattern. The distances given in the right sides of the two diagrams are similarly used in connection with those of the upper halves of the two openings, all of which are indicated by figures bearing primes, in developing that portion of the pattern to the right of D C. Lines traced through the various intersections of arcs thus obtained, as shown by A E E^1 A^1 and B^1 H F B, will give the required pattern of the shoe.

PATTERN FOR OBLIQUE ELBOW IN SQUARE PIPE

Fig. 43 is sketch of leader elbow to make turn at a corner of a building. A shows the pipe on one side of the building and B on the other, both being connected by the elbow C. While the correct crook or bend can be obtained it would not help us any to know, because the pipes on either wall must be of different profiles, so as to allow the two rear sides of the pipe to lay flat against the walls of the building. If the correct bend was obtained and the same profile used in both pieces of the elbow, one side would lay flat against one side

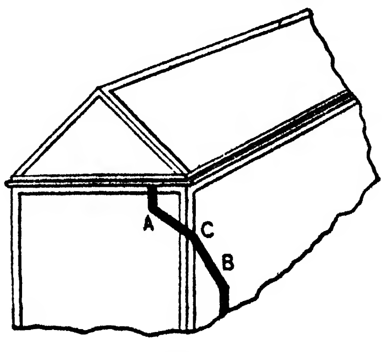


Fig. 43

of the building, while on the other side the corner of the pipe would only touch the wall. The principles hereinafter shown will apply to square, rectangular, oval, round, octagonal or any other shaped pipe, whatever may be the plan or corner of the building. In Fig. 44 let H I represent one side of the elbow

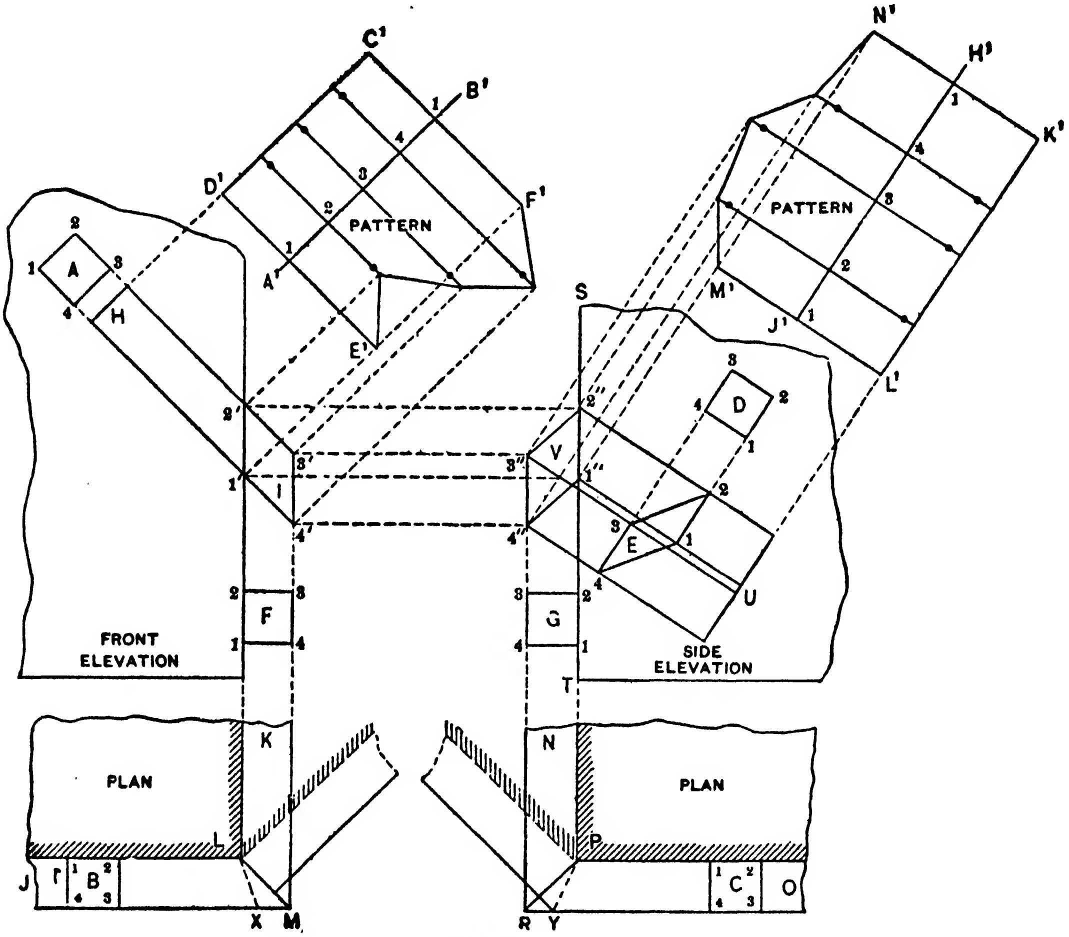


Fig. 44. Plans, Elevations and Patterns

placed against the wall at its proper angle and A be the profile of the pipe, numbered 1, 2, 3 and 4. Directly under the elevation draw a plan view of the pipe, as shown by J K, the section of the pipe being indicated at B and numbered 1, 2, 3 and 4. Draw the miter line L M. Now from the intersections on the miter, which in this case are only two points, L and M, carry lines upward at right angles to J M, intersecting lines of similar numbers carried parallel to the lines of the pipe in front elevation H I, as shown by 1′, 2′, 3′ and 4′, these representing the line of joint in front elevation.

Now draw any vertical line, as S T, which will represent the line of the wall in side elevation. In line with S T draw the plan, as shown by N O, the profile of

the pipe being indicated by C; draw the miter line P R. Now at right angles to O R in plan and from intersections on the miter line carry lines upward, intersecting those of similar numbers drawn at right angles from $1'$, $2'$, $3'$ and $4'$, as shown by $1''$, $2''$, $3''$ and $4''$.

From these latter intersections draw the lines of the pipe in side elevation at their proper angle, as shown by V U, in which a change of profile occurs, to allow the joining at the corner at their respective angles.

In this connection it may be proper to remark that the normal or given profile has been placed in the front elevation at A, while the profile in the side elevation will be modified to suit. If desired the given profile could be placed in the side

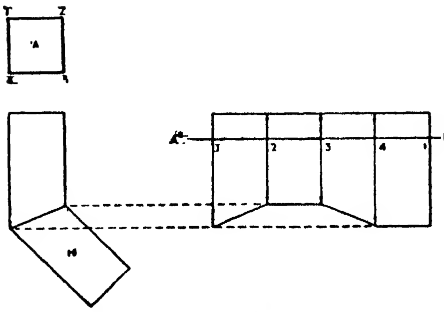


Fig. 45

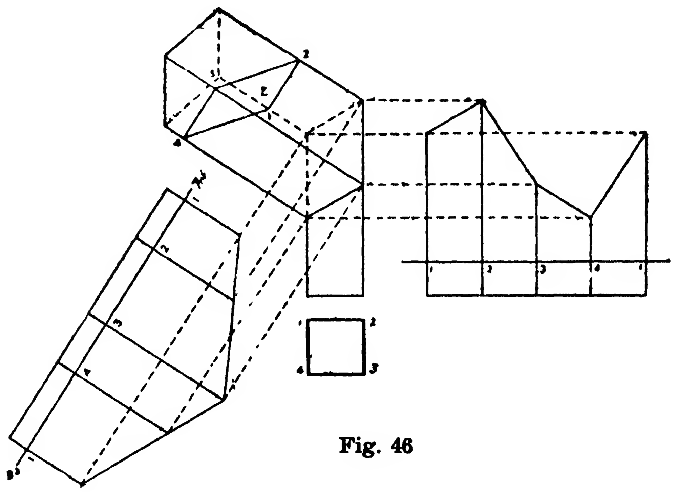


Fig. 46

and the one in front modified, as seems most convenient. To obtain the change of profile in the side elevation, place the given profile D, numbered 1 to 4, at right angles to the line of the pipe. From the small figures drop lines at right angles to the line of the pipe, intersecting lines of similar numbers drawn from the intersections $1''$ to $4''$. Draw lines from points of intersections thus obtained, then will E be the profile or shape of pipe for the side elevation.

For the pattern for the arm of the elbow in the front view proceed as follows: At right angles to H I draw the line A^1 B^1, upon which place the stretchout of the profile A, as shown by the small figures 1 to 1. At right angles to A^1 B^1 and through the small figures draw lines, intersecting those of similar numbers drawn at right angles to H I from the line of joint $1'$, $2'$, $3'$ and $4'$. Trace a line through the points thus obtained, and C^1, D^1, E^1 and F^1 will be pattern for the front arm of the elbow.

For the pattern for the side arm, draw at right angles to V U the line H^1 J^1, upon which place the stretchout of the profile E, as shown by the small figures.

At right angles to H^1 J^1 and through the small figures draw lines intersecting those of similar numbers drawn at right angles to V U of the pipe from the intersections 1″ to 4″.

Trace a line through the intersections thus obtained, and K^1 L^1 M^1 and N^1 will be the pattern for the arm of the elbow in the side view, which must be bent after the profile E. For the pattern of miter at B, Fig. 43, place V U and profile A as shown in Fig. 45. Project lines from A to meet like numbered lines from V U, getting miter lines 1^B, 2^B, 3^B, 4^B. For pattern of this draw line A^8 B^8 at right angles, 2^B, 3^B, on which place stretchout of A; from these points draw lines at right angle to A^8 B^3, and intersect with lines drawn from miter lines as indicated. Repeat for modified arm, using stretchout of E, as shown by line A^8, B^8.

Pattern of miter at A, Fig. 43, is obtained by placing H, as shown in Fig. 46, and proceeding as directed for other patterns.

In case the corners of the building were not at right angles, but had an angle as indicated in the two plans by dotted lines, then instead of drawing lines upward from the miter lines L M and P R lines would be carried upward from the miter lines L X and P Y. When the corner of the building is square a plan is not required, it only being necessary to place the profiles as at F and G in the front and side views and carry up lines from these points. The plan views would only be placed in position in this case to show the application of the principles involved. No matter what angle the corner has the points of projection are carried up from the miter line in plan as shown.

PATTERN FOR COMPOUND TWISTED ELBOW

To obtain the patterns for a compound twisted elbow, as shown in Fig. 47, it is important in this case that the elbow have the same dimensions throughout its entire form and that the side curves run perfectly parallel to each other, so that when viewed from either side the curves will be graceful and parallel with each other. Referring to Fig. 47, which is a sketch of the required article, let A B C D in plan represent the top of the elbow and A^1 B^1 C^1 D^1 the bottom, the elbow making a quarter turn in plan, which reverses the sections of the pipe. D^8 C^8 C^8 B^8 shows the elevation, giving a general view of the twist.

As it is desirable that the side curves of the elbow must run perfectly parallel to each other, it will be impossible to first draw the elevation, as the development

of the sides must first be obtained and the elevation projected from it. Therefore, in Fig. 48, let A B C D be the plan of the top of the elbow and A^1 B^1 C^1 D^1 the plan of the bottom. Let J represent the center, from which the arcs A D^1 and B C^1 are struck, showing the quarter turn which the elbow is to make in plan.

Before constructing the elevation it will be necessary to lay out the patterns for the inner and outer curve, as follows: Divide the outer curve A D^1 into equal spaces, as shown by the small figures 1 to 4. In similar manner divide the inner curve B C^1 into similar parts, as shown by the figures 1′ to 4′. Draw, as in Fig.

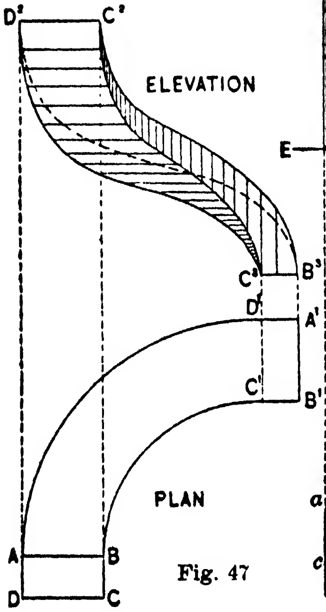


Fig. 47

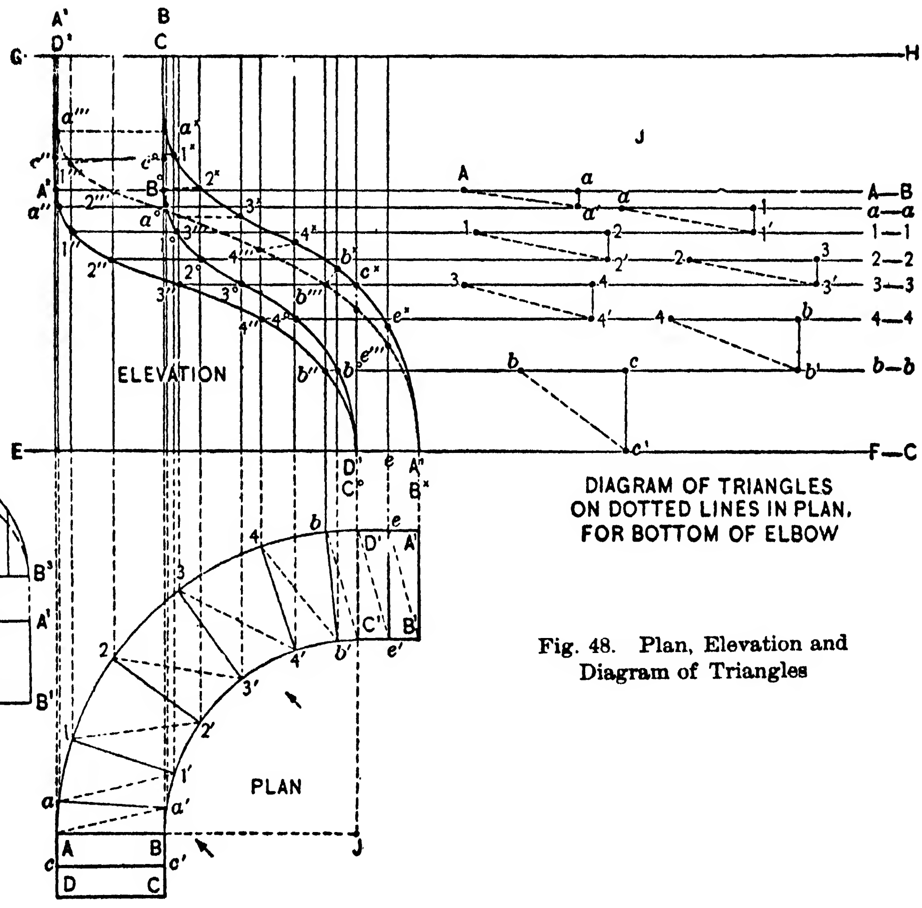


Fig. 48. Plan, Elevation and Diagram of Triangles

49, any horizontal line, as E F, upon which place the stretchout of the outer curve in plan in Fig. 48, D A 1 2 3 4 D^1 A^1, as shown by D A 1 2 3 4 D^1 A^1 on the line E F of Fig. 49, at right angles to which and from the small figures erect vertical lines, as shown. Assuming that the hight of the elbow is to be as much as indicated by E G, draw the line G H parallel to E F, as shown. As D A and D^1 A, on the line E F represent the narrow sides of the section of the elbow, extend the points D and A until they intersect the line G H at D^2 and A^8. From D^8 draw at

pleasure a graceful free hand curve to D^1, as shown by $D^2\ 2''\ D^1$, intersecting the vertical lines previously drawn, as shown by A^2, $1''$, $2''$, $3''$ and $4''$. Now set the dividers equal to $D^2\ A^3$ or $D^1\ A^1$ and draw a curve parallel to $D^2\ 2''\ D^1$, as shown by $A^3\ 3'''\ A^1$, intersecting the vertical lines at $1'''$, $2'''$, $3'''$, $4'''$ and D^3; then will $D^2\ A^3\ 3'''\ A^1\ D^1\ 2''\ D^2$ be the pattern for the outside curve of elbow, the lines of which run parallel to each other on the line D A^1 in plan of Fig. 48. As the curves between the points $A^3\ 1'''$, $D^3\ A^1$, $D^1\ 4''$ and $A^2\ D^2$ of Fig. 49 become rather wide establish an extra point between each, as shown by a''', e''', b'' and c'', respectively. From these points drop vertical lines onto the line E F, as follows: From c'' drop a line, obtaining the point c on E F. Now take the distance from D to c and place it from D to c in plan in Fig. 48, and from c draw a line parallel to D C, as shown by $c\ c'$. In the same manner, from a''' in Fig. 49 drop a line, intersecting the lower curve at a'' and the line E F at a. Take the distance from A to a and place it as shown from A to a in plan, Fig. 48. In the same manner in Fig. 49, from point b'', draw a vertical line, extending it upward until it intersects the upper curve at b''' and the line E F at b. From the point e''' drop a line, intersecting E F at e. Now take the distance from A^1 to e and place it in plan, Fig. 48, as shown, from A^1 to e. From e draw a line parallel to, $A^1\ B^1$ as shown by $e\ e'$. Finally, take the distance from 4 to b of Fig. 49 and place it in plan in Fig. 48, as shown, from 4 to b.

In Fig. 48 draw any horizontal line, as E F, and take the distance from E to G in Fig. 49 and place it from E to G in Fig. 48. From G draw a line parallel to E F, as shown by G H. At right angles to E F and from all the points on the outer curve D A^1 in plan erect vertical lines, as shown. Measuring in each instance from the line E F of Fig. 49, take the various hights to the point D^2, c'', A^2, a'', $1''$, $2''$, $3''$, $4''$ and b'' on the lower curve and place them in Fig. 48, measuring in every instance from the line E F on lines drawn from similar numbered points in plan, thus locating in elevation the points D^2, c'', A^2, a'', $1''$, $2''$, $3''$, $4''$, b'' and D^1. A line traced through the points thus obtained will represent the miter line in elevation for the bottom line of the outside curve.

To obtain in elevation the top line of the outer curve, take the various distances in Fig. 49 to points A^3, a''', $1'''$, $2'''$, $3'''$, $4'''$, b''', D^3, e''' and A^1, measuring in each instance from the line E F, and place them in elevation in Fig. 48, measuring in every instance from the line E F onto lines having similar numbers drawn from the outer curve in plan, thus establishing the points or intersections A^3, a''', $1'''$, $2'''$, $3'''$, $4'''$, b''', D^3, e''', A^1, as shown by the dotted line. This would complete the true elevation of the outer curve in plan to correspond to the plan and the development of the outer curve in Fig. 49.

Before obtaining the elevation of the inner curve it will first be necessary to obtain the pattern for the inner curve, for which proceed as follows: Take the stretchout of the inner curve in plan, Fig. 48, as shown by the points C, c', B, $1'$, $2'$, $3'$, $4'$, C^1, e', B^1, and place them on the line G H of Fig. 49, as shown by the points C, c', B, $1'$, $2'$, $3'$, $4'$, C^1, e' and B^1. At right angles to G H and from these points drop vertical lines, which intersect with others drawn parallel to G H from similar numbered points on the lower curve D^2 D^1, thus obtaining the intersections c°, B°, 1°, 2°, 3°, 4°, C°. A line traced through these points, as shown, will be the lower cut for the pattern for the inner curve.

As that portion of the elbow shown in plan in Fig. 48 by D A and C B is perfectly straight and has no twist from D^2 to A^2 and from C to B° in elevation, the curve shown in Fig 49 by C c° B° will be a tracing of D^2 c'' A^2. Now set the

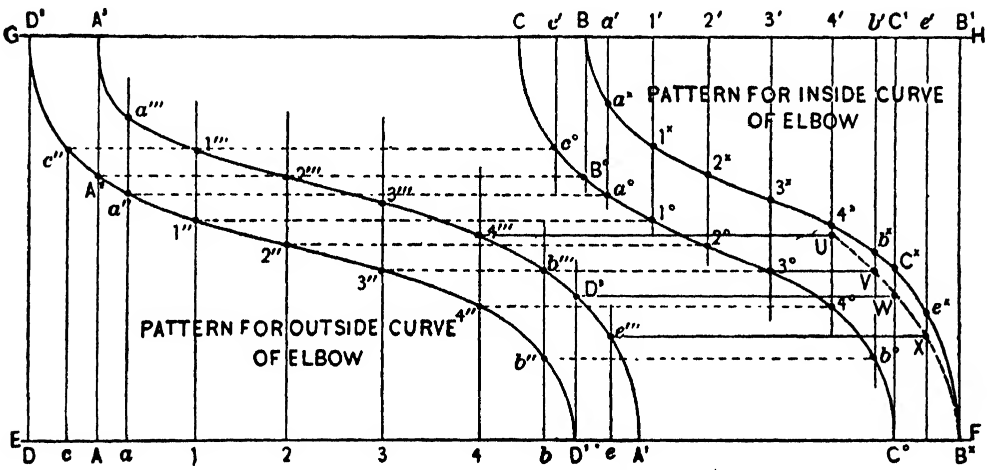


Fig. 49. Method of Obtaining Patterns of Sides of Elbow

dividers equal to C B or C° B^x and draw a curve parallel to C 2° C°, as shown by B 3^x B^x, intersecting similar numbered vertical lines at 1^x, 2^x, 3^x, 4^x, C^x, e^x and B^x. Then will C 2° C° B^x 3^x B be the pattern for the inside curve of the elbow.

As the curves between B and 1^x and 4° and C° are rather wide, introduce extra points, as a^x and b°, drawing vertical lines from these points until they intersect the lower and upper curves at a° and b^x and the line G H at a' and b', respectively.

Take the distances from B to a' and from $4'$ to b' and place them in plan in Fig. 48 from B to a' and from $4'$ to b, respectively, as shown. Now from all the points contained in the inner curve in the plan erect vertical lines, as shown, into the elevation until they intersect the top line of the elbow G H. Measuring in every instance from the line G H of Fig. 49, take the various hights to points c°, B°, a°,

1°, 2°, 3°, 4°, b° and C° and place them in elevation, Fig. 48, measuring in each instance from the line G H, on lines drawn from similar numbered points in plan, thus locating the points C, c°, B°, a°, 1°, 2°, 3°, 4°, b°, C°. A line traced through the points thus obtained will represent the miter line for the bottom line of the inside curve.

In similar manner measuring from the line G H in Fig. 49, take the various distances to points B a^x, 1^x, 2^x, 3^x, 4^x, b^x, C^x, e^x and B^x and place them in elevation, Fig. 48, measuring from the line G H on vertical lines of similar numbers, thus obtaining the intersections B, a^x, 1^x, 2^x, 3^x, 4^x, b^x, C^x, e^x, B^x. A line traced through these points will represent the miter line for the top line of the inside curve of the elbow, and D^2 D^1 A^1 C will represent the elevation of the elbow, shown in plan by D A^1 B^1 C, whose side developments are equal to those shown in Fig. 49.

Referring to the patterns in Fig. 49, it will be noticed that the point A^2 in the pattern for outside curve intersects with the vertical line B in the pattern for inside curve, because the corners in the section in plan, Fig. 48, are lettered A and B. This is mentioned so as not to confuse the reader. As the patterns for the top and bottom will be developed by triangulation, for which diagrams of triangles must be constructed, therefore draw the base lines in plan by connecting similar points, as shown by a a', 1 1$'$, 2 2$'$, 3 3$'$, 4 4$'$, b b' and e e', for solid line triangles, and A a', a 1$'$, 1 2$'$, 2 3$'$, 3 4$'$, 4 b', b C^1, D^1 e' and e B^1 for dotted line triangles. Thus the sections shown in elevation represent sections on similar numbered lines in plan. For example, $1''$ 1° 1^x $1'''$ is a section on 1 1$'$ in plan, as is $4''$ 4° 4^x $4'''$ a section on 4 4$'$ in plan, etc. It will be noticed that the bottom lines of the sections in elevation all run in a horizontal plane, while the top are slightly raised on the upper line of the inner curve B 4^x B^x. This occurs because the line B 3^x B^x in Fig. 49 is drawn parallel to the curve C 2° C°. If it was desired that the top of the elbow in elevation, Fig. 48, was to show horizontal planes the same as the bottom then in Fig. 49 horizontal lines would have to be carried from points a''', $1'''$, $2'''$, $3'''$, $4'''$, etc., on the curve A^3 $3'''$ A^1 and intersected with the vertical lines a', $1'$, $2'$, $3'$, $4'$, etc., in the same manner as the points C'', A^2, a'', $1''$, $2''$, $3''$ etc., were intersected with the vertical lines c', B, a', $1'$, $2'$, $3'$, etc., in the pattern for inside curve, and would result in an unequal line, as shown partly by the dotted line u v w x B^x in the pattern for the inner curve. It is better to have a slight incline toward the top of the elbow, which cannot be seen, than to have an unequal line such as the dotted one u v w x B^x would show when viewed from the arrow lines in plan, Fig. 48.

As the solid lines in elevation of bottom of elbow have horizontal planes, then

no diagram of triangles will be required on solid lines in plan, the lines there shown in plan being the actual distances. However, diagrams on dotted lines in plan must be obtained, as follows: From the various points in elevation on the two miter lines representing the bottom of the elbow draw lines to the right of the elevation, as shown by lines A B, *a a*, 1 1, 2 2, 3 3, 4 4, *b b* and F C, which represent the hights in elevation of similar points in plan for the bottom. Now take the lengths of the dotted lines in plan and place them on lines having similar numbers in the diagram of triangles, as follows: For example, take the distance of A a' in plan, place it on the line A B in J, as shown by A *a*. At right angles to A *a* draw the line *a* a', intersecting the line *a a* at a'; draw a line from a' to A, which is the true distance on A a' in plan. In similar manner take the distance of

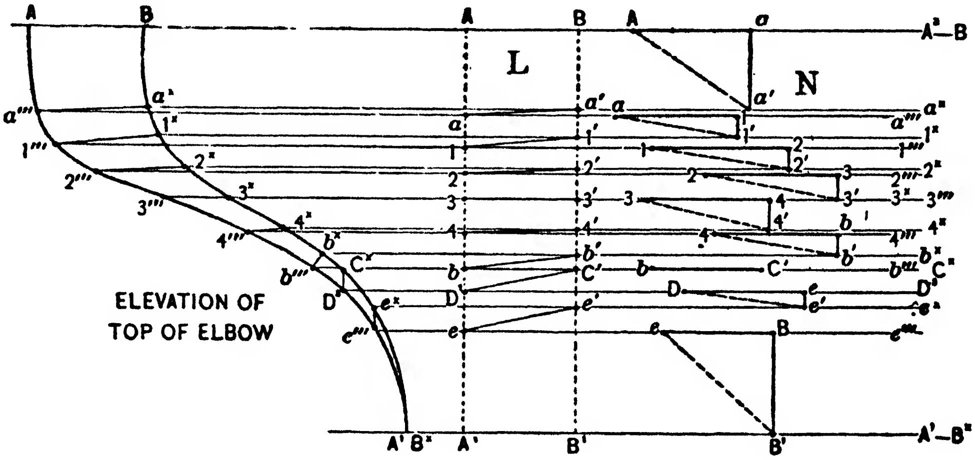


Fig. 50. Part Elevation, with Diagram of Triangles on Solid and Dotted Lines in Plan, Fig. 48, for Top of Elbow

2 $3'$ in plan and place it on 2 2 in J, as shown by 2 3, at right angles to which and from the point 3 draw the line 3 $3'$, intersecting the line 3 3 at $3'$. Then a line drawn from $3'$ to 2 will be the actual distance on $3'$ 2 in plan. Proceed in this manner until all of the triangles have been obtained.

As the top of the elbow shown in elevation does not run on a horizontal plane, diagrams of triangles on dotted and solid lines must be obtained. To avoid a confusion of lines take a tracing of A^3, $3'''$, A^1, B^x, 3^x, B, which represent the miter lines for the top of the elbow in elevation, and place it with the various points of intersections on same, as shown by similar numbered points in elevation, Fig. 50. From these points draw horizontal lines to the right, as shown by the lines having similar numbers, as A^8 B, a^x a''', 1^x $1''$, 2^x $2'''$, 3^x $3'''$, 4^x $4'''$, b^x b''', C^x D^8, e^x e''' and A^1 B^x. As the lengths of all the solid lines in plan, Fig. 48, are equal, take the length of A B and place it as shown by A B on the line A^8 B in L of Fig.

50. From the points A and B drop vertical lines, intersecting all the horizontal lines to A^1 B^1 on the line A^1 B^x. Now from the points of intersections on the horizontal lines draw lines connecting lines having similar figures or letters, as *a a′*, 1 1′, 2 2′, 3 3′, 4 4′, *b b′*, D^1 C^1 and *e e′*, which represent the actual distances on solid lines having similar letters or figures in plan 48.

For the triangles on dotted lines in plan proceed in the same manner as shown in J in elevation. For example, take the distance 3 4′ in plan and place it on the line 3^x 3‴, as shown by 3 4, in N in Fig. 50. From 4, at right angles to 3 4, draw the line 4 4′, intersecting the line 4^x at 4′. Draw a line from 4′ to 3, which represents the true length on the line 4′ 3 in plan, Fig. 48. Proceed in similar manner for the balance of the triangles on dotted lines shown in N of Fig 50.

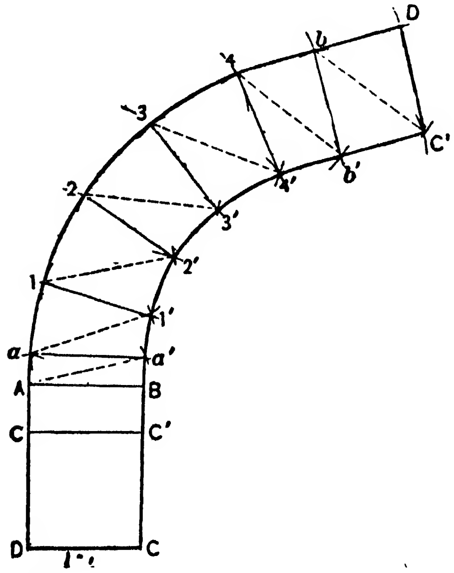


Fig. 51. Pattern for Bottom of Elbow

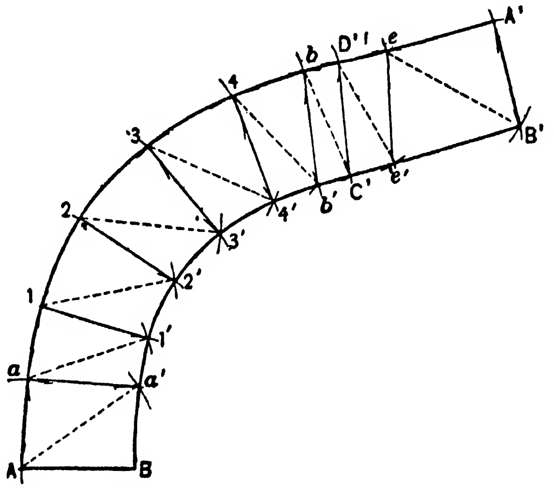


Fig. 52. Pattern for Top of Elbow

For the pattern for the bottom of the elbow draw any horizontal line, as D C of Fig. 51, equal to D C in plan, Fig. 48. Now take the stretchout of D^2 *c″* A^2 on the pattern for outside curve, which also equals C *c°* B° in the pattern for inside curve, and place it, as shown in Fig. 51 by D *c* A and C *c′* B, respectively, at right angles to D C. Now, with B as center and B° *a°* of Fig. 49 as radius describe the arc *a′* of Fig. 51. Then, with A as center and A *a′* in J of Fig. 48 as radius, intersect the arc *a′* of Fig. 51. With A as center and A^2 *a″* of Fig. 49 as radius describe the arc *a* of Fig. 51, which intersect with an arc struck from the center A with a radius equal to *a a′* in plan in Fig 48. Proceed in this manner, using alternately as radii first the spaces on the lower curve in the pattern for inside curve in Fig. 49, then the lengths of the hypotenuses in J of Fig. 48, the lengths of the spaces on the lower curve in the pattern

for outside curve in Fig. 49, then the lengths of the solid lines in plan, Fig. 48, until the last line, D^1 C^1 of Fig. 51, has been obtained. A line traced through these intersections, as shown by D^1 C^1 $2'$ C D 2 D^1, will be the pattern for the bottom of the elbow. For the pattern for the top of the elbow draw any horizontal line, as A B in Fig. 52, equal to A B in plan, Fig. 48. Now, with B a^x in pattern for inside curve as radius in Fig. 49 and B of Fig. 52 as center, describe the arc a'. Then, with A as center and A a' in diagram N of Fig. 50 as radius, intersect the arc a' of Fig. 52. Then, with A^3 a''' in the pattern for outside curve in Fig. 49 as radius and A of Fig. 52 as center, describe the arc a. Now, using a' as center and a a' in diagram L in Fig. 50 as radius, intersect the arc a of Fig. 52, as shown. Proceed in this manner, using alternately as radii first the spaces on the upper curve in the pattern for inside curve of elbow in Fig. 49, then the lengths of the hypotenuses in diagram N of Fig. 50; third, the lengths of the spaces in the upper curve in the pattern for outside curve of elbow in Fig. 49, then, finally, the lengths of the solid lines in diagram L of Fig. 50, until the last line, A^1 B^1 of Fig. 52, is obtained. A line traced through these intersections, as shown by A^1 B^1 $3'$ B A 3 A^1, will be the pattern for the top of the elbow.

PATTERN FOR A DOUBLE OFFSET IN SQUARE LEADER

To obtain the pattern for the offset, backset, compound curved article shown in Fig. 53 that throws back and sideways at the same time with an easy, graceful bend, so designed that it can be made with a joint in the middle allowing of greater ease for double seaming, and so the patterns for one-half of offset can be used for upper or lower sections, proceed as follows:

In Fig. 53 is shown a sketch of problem. It will be noticed that the front of the offset projects 5 inches from the face of the wall, and the side of the offset 8 inches from the wall line. The size of the leader is 3 × 4 inches, the entire hight of the offset being 20 inches. Last, it may be stated that it is not possible to make the joints as indicated in Fig. 53 when the lower section is used for the upper one, or right and left. The joint would have to be horizontal, as shown by 19 18 and 6 7 of Fig. 54. In Fig. 54 are shown front and side views and the method of obtaining the patterns. All the measurements shown in Fig. 53 have been followed, as is indicated in Fig. 54. The essential thing is to obtain the line of joint which divides the offset into two halves, so that the upper half can be used for the lower half, each having the same curve or sweep, placed in a different

dimension. To obtain the proper curve and line of joint proceed as follows: Referring to Fig. 54, let B A in the side view represent the distance of 8 inches, and A C the 3-inch width of pipe; bisect the distance B C, or 11 inches, as shown at K;

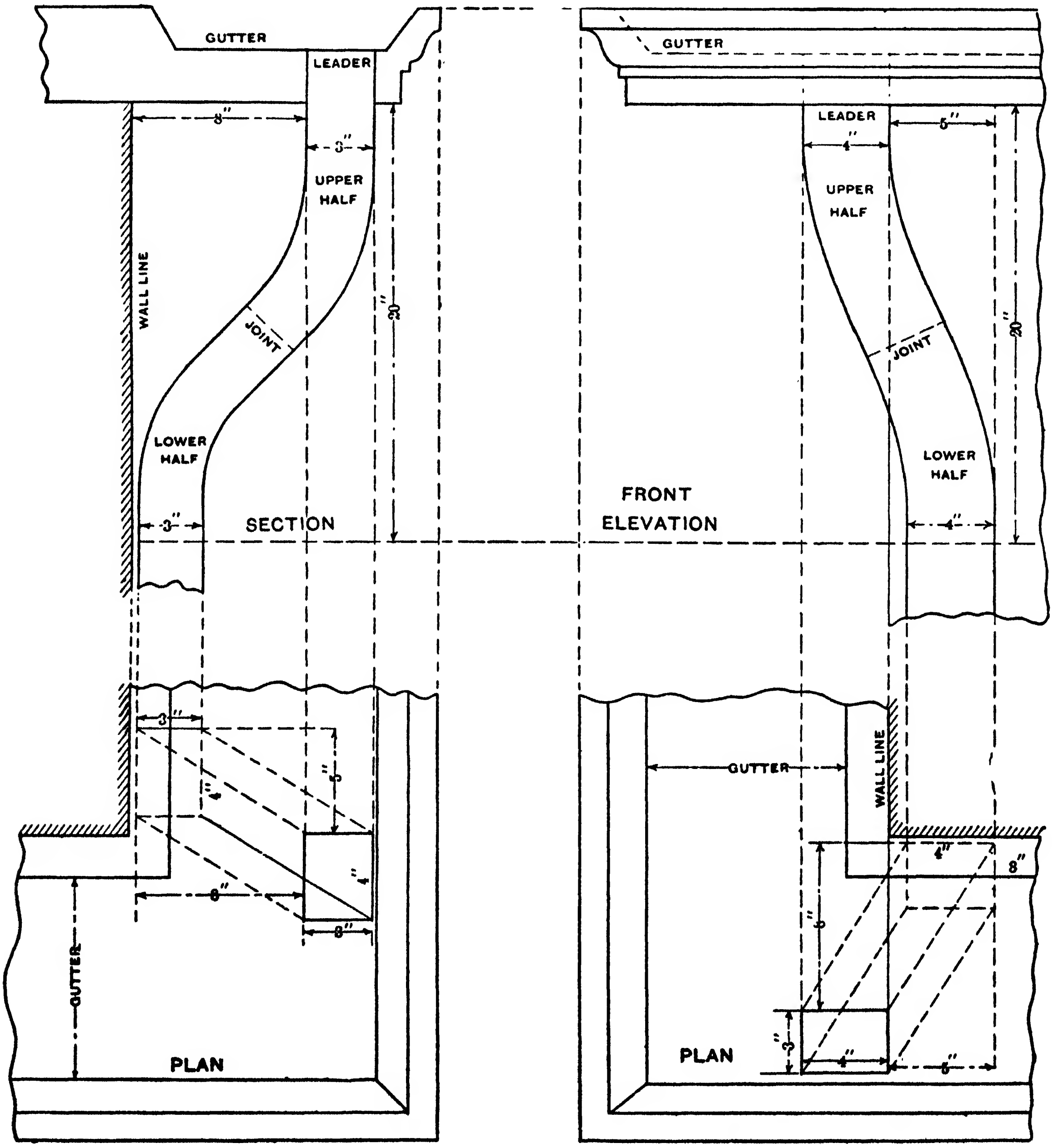


Fig. 53

bisect the width of the pipe A C, as shown at O. At right angles to B C, and from the point K, draw a line, as shown by K M. Now bisect the distance G H, or 20 inches, as shown at J. At right angles to G H, and through the point J, draw the

line J M, intersecting the line K M at M. Now at pleasure draw a curve, shown from O to M. Parallel to the curve O M, from the point C, draw the curve C 18; likewise parallel to O M, from the point A, draw the curve A 19. Then will A C 18 19 represent the upper half of the side view of the offset, which is reversed and traced to the lower part, as shown by 18 19 R S. For the upper half of the front view of offset the same methods are employed. Let E D represent the 5-inch and D F the front width of the pipe, 4 inches. Bisect F E, or 9 inches, as shown at L, from which drop a line at right angles to F E, intersecting the line M N at N.

Now bisect the distance F D, or 4 inches, as shown at P. Draw a curve from P to N. Now parallel to the curve P N, from the points F and D, draw the curved lines D 7 and F 6. Then will F D 7 6 represent the upper half of the front of offset, which is traced below on the line 6 7, as shown by 6 7 U T.

We have now the two upper halves of the side and front of offset, which can also be used for the lower halves, or right and left, placed in a given dimension. For the patterns proceed as follows: Divide any one of the curves in the front or side views into equal spaces, as shown in this case from F to 6 in front view.

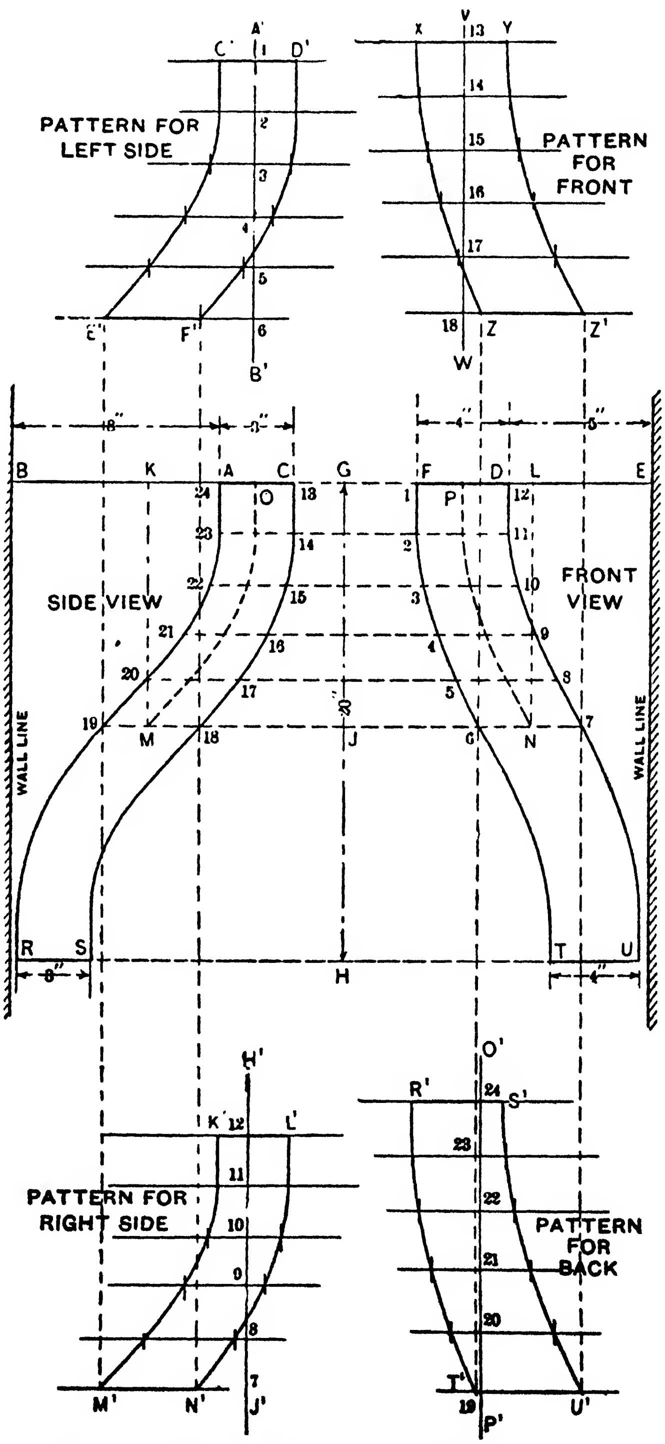


Fig. 54. Front and Side Views and Half Patterns

Through the points obtained in the curve F 6, and parallel to F D, draw lines intersecting the curve in the front view L 7, and the curves in the side view C 18 and 19 A, as shown by the small figures. It should be understood that only one curve, namely, F 6 in front view, has been divided into equal spaces; the other spaces on the other curves will be unequal, and when obtaining the stretchout of these curves every space must be transferred separately. This has been done to avoid a confusion of lines, which would occur if each curve was divided independently. For the pattern for the front draw any line, as V W, at right angles to F D, upon which place the stretchout of the profile of the front, shown by C 18 in side view, as shown by the small figures from 13 to 18 on the stretchout line V W. At right angles to V W, and through points on same, draw the usual measuring lines, which intersect with lines drawn at right angles to F D from points in F 6 and D 7 of the front view. Lines traced through points of intersection thus obtained, as shown by X Z and Y Z^1, will represent the pattern for the half front. It will be noticed that the lines of projection have been omitted in the drawing, except the two intersecting the line 18 in pattern. This method will be followed on all the patterns so as to avoid a confusion of lines. For the pattern for the back of the offset draw any line, as O^1 P^1, at right angles to T U in front view, upon which place the stretchout of the profile for the back of offset, shown by A 19 in side view, as shown by the same figures. At right angles to O^1 P^1, and through points on same, draw the usual measuring lines, which intersect with lines drawn at right angles to T U from points in F 6 and D 6 of the front view. Lines traced through these points of intersection, shown by R^1 T^1 and S^1 U^1, will be the pattern for the back of the offset.

For the pattern for the left side of the offset draw any line, as A^1 B^1, at right angles to A C in side view, upon which place the stretchout of the profile for left side of offset, shown from F to 6 in front view, as shown by the small figures. At right angles to A^1 B^1, and through points on same, draw measuring lines, which intersect with lines drawn at right angles to A C from points in A 19 and C 18 of the side view. Lines traced through these points of intersection, as shown by C^1 E^1 and D^1 F^1, will be the pattern for the left side of the offset. For the pattern for right side of offset draw any line, as H^1 J^1, at right angles to R S in side view, upon which place the stretchout of the profile for right side of offset, shown from D to 7 in front view, as shown by the small figures. At right angles to H^1 J^1, and through points on same, draw measuring lines, which intersect with lines drawn at right angles to R S from points in A 19 and C 18 of the side view. Lines traced through points of intersection thus obtained, as shown by K^1 M^1 and L^1 N^1, will be the pattern for the right side of the offset. Allowance should be made for edges for double seaming.

COMPOUND TWISTED ELBOW WITH A PANELED FACE

To make an elbow similar to preceding problem, excepting that this has a paneled front, it is suggested that front be made in one piece because of structural strength allowing for greater resistance to bursting pressure of ice if frozen. Therefore construct the leader as if it were square and had no paneled front, by the rule given in last problem which when completed will look as shown in Fig. 56 at A. When putting this model together use galvanized iron and tack it together on the outside raw edge and solder a flat bottom on one end, as at *a*. Now, oil the inside well, and fill it with plaster of paris, which the oil will keep from adhering to the sides of the elbow. When the cast is hard, then carefully loosen the tacks on the corners of the metal elbow and we have a plaster cast. While the plaster is still moist, cut in the panel as required, dry well, give a good coat of shellac and have a cast made at the iron foundry, which will cost but a few cents per pound. Then, using the galvanized iron patterns, cut new ones, allowing laps for seaming, after which the face or front is laid upon the iron die and worked into the desired shape, as shown by C in diagram B. When a number are to be made an opposite die is formed of lead, when the pieces can be stamped out much quicker than when done by hand. When copper is called for, use soft copper for the paneled front, which works itself well into the shape.

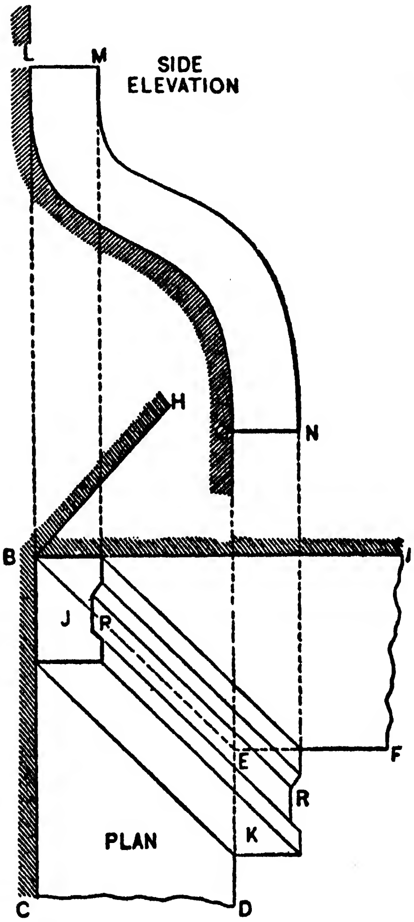


Fig. 55. Leader Pipe Elbow. Plan and Front Elevation of Elbow

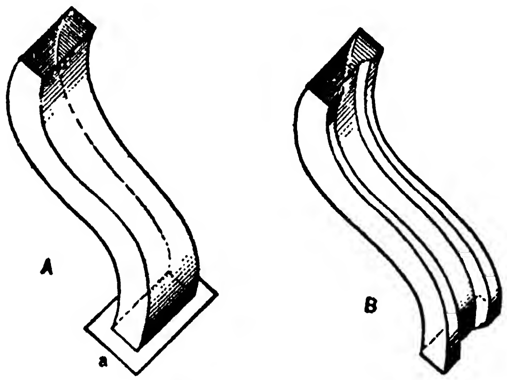


Fig. 56. Obtaining Models

PATTERNS FOR A COMPOUND PANELED LEADER ELBOW

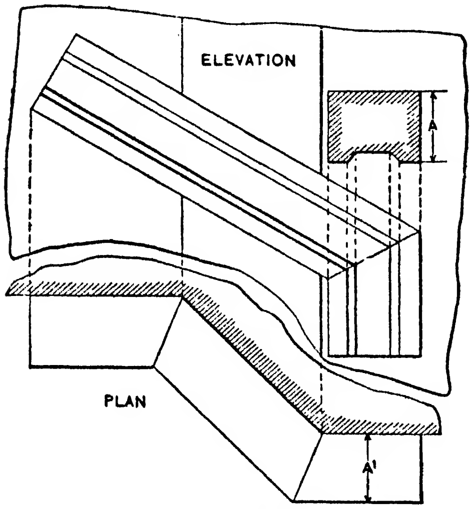


Fig. 57

To develop the patterns for a paneled leader elbow, as indicated in the plan and elevation in Fig. 57, in which the section of the leader is shown by A. The sketch shows a vertical leader in elevation, joining an inclined leader at a given angle, the inclined leader to have elbows or breaks to suit the angles of the wall shown in plan.

The first step is to draw the plan and elevation, in which the miter lines of the elbow are correctly projected into the elevation. This is accomplished as shown in Fig. 58, in which A B C D represents the angles of the wall in plan. The paneled leader is to be placed as shown by J F H K, E representing the section of the leader. L M N O P R shows the elevation of the leader, placed at an angle shown by L M N.

In its proper position, in line with the raking leader M N O P, place a duplicate of the profile E, as shown by E^1. In a similar manner, in line with the vertical leader M L R P, draw a section of the leader, as shown in plan dotted, the corners being numbered from 1 to 8. Number the corners in profiles E and E^1; also from 1 to 8, and draw the panel lines in the elevation as shown, which will produce a face miter in elevation shown from M to P and numbered 1 to 8.

To obtain the miter lines in elevation showing the joint or intersection of the angles B F and C H in plan, proceed as follows: From the various intersections 1 to 8 in the profile E in plan draw lines parallel to the lines of the pipe, intersecting each other at the angles B F and C H from 1 to 8, as shown. From these intersections erect vertical lines, intersecting similar numbered lines in the inclined leader in elevation, and resulting in the miter lines 1 to 8 in *d* and *e*.

The entire elbow now consists of four pieces, which have been numbered in elevation I, II, III and IV.

The pieces I, II and IV have a profile similar to E or E^1, while the piece III will require a change of profile to admit the mitering between pieces II and IV.

For the patterns for the pieces II and IV extend the line O N in elevation as S T, on which place the stretchout of E or E^1, as shown by the small figures 1 to 8 to 1. Through these at right angles to S T draw lines indefinitely as shown,

which intersect by lines drawn at right angles to the leader N M from similar intersections in the miter lines *d* and *e*; also from similar intersections in the miter line M P. Trace a line through points thus obtained. Then will S T U V be the pattern for piece IV and W X Y Z the pattern for piece II.

For want of space in Fig. 58, the pattern for piece I is shown developed in

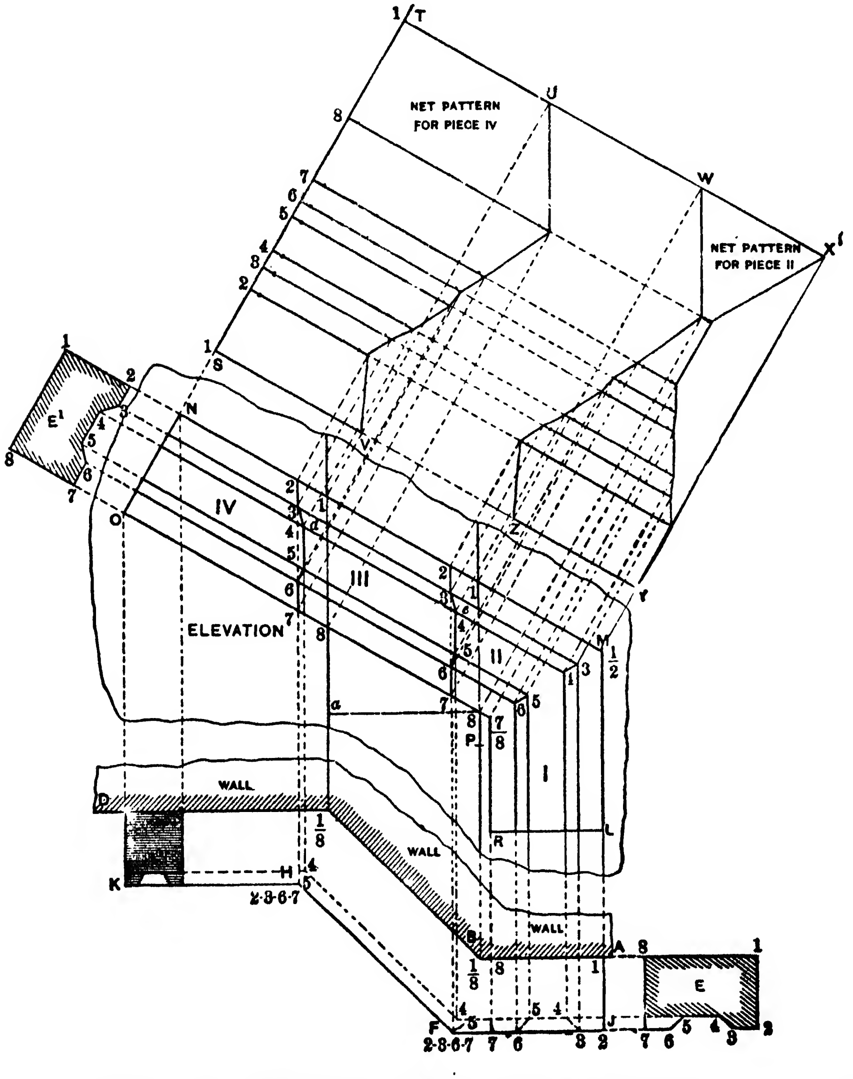


Fig. 58. Plan, Elevation and Patterns for Pieces II and IV

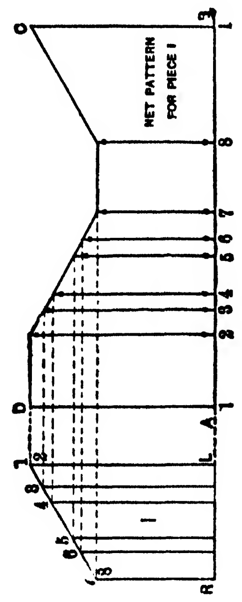


Fig. 59. Pattern for Piece I

Fig. 59, in which I is a reproduction of I in Fig. 58. On R L, extended as A B in Fig. 59, place the girth of the profile E in Fig. 58, as shown by similar numbers in Fig. 59. Draw the usual measuring lines, which intersect by lines drawn parallel to A B from similar points on the miter line in I. A line traced through these points, as shown by A B C D, will be the pattern for piece I.

Before the pattern for piece III can be obtained a true elevation and modified profile must be found, as follows: Take a tracing of the plan shown in Fig. 58, by C B F H and place it in a horizontal position shown by similar letters and figures in Fig. 60. In similar manner take a tracing of the foreshortened elevation of piece III, in Fig. 58, with the miter lines *d* and *e* and the various intersections on same, and place it in Fig. 60 to one side and above the plan, being careful that the dotted line *a* 8 is placed in a horizontal position as shown by III.

At right angles to C B in plan from the various intersections 1 to 8 on each side erect vertical lines, which intersect by horizontal lines drawn from similar numbered intersections in the miter lines *d* and *e* in the foreshortened elevation. Through points thus obtained in III° trace a line and connect similar points, resulting in the true elevations. Extend the lines in the true elevation and at right angles to these place a duplicate of the profile E as shown. At right angles to the lines in the true elevation draw lines from the various numbers in E, intersecting the similar numbered extended lines, and resulting in the true profile there shown.

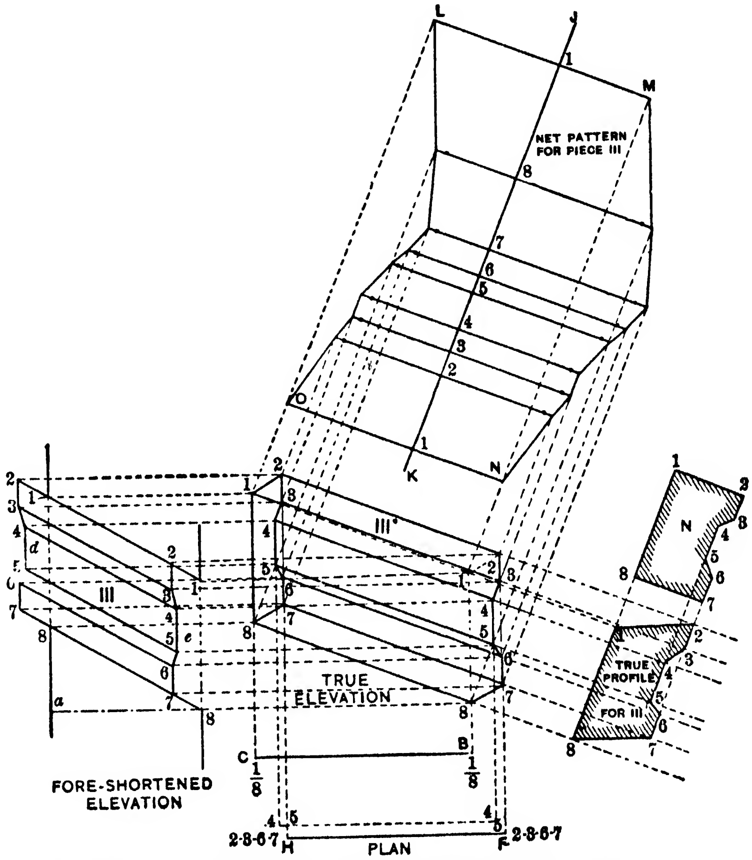


Fig. 60. True Elevation, Profile and Pattern for Piece III

For the pattern for the piece III take the girth of this true profile, and place it on the line J K drawn at right angles to the true elevation. Draw the usual measuring lines, which intersect by lines drawn parallel to J K from the miter lines at the top and bottom of the true elevation. A line traced through points thus obtained, as shown by L M N O, will be the desired pattern.

PATTERNS FOR A COMPOUND PANELED LEADER ELBOW, MAINTAINING THROUGHOUT GIVEN PROFILE

For the foregoing problem it may be mentioned that piece III need not be raked; should it be desired to maintain given shape and area of leader throughout and it is immaterial if leader does not absolutely follow contour of wall. Then the problem would be to ascertain true angle at H and F, Fig. 58, and cut an elbow for this angle. It may also be said that having the true angle, a stay can be cut, greatly facilitating the soldering together of the different pieces in the last problem.

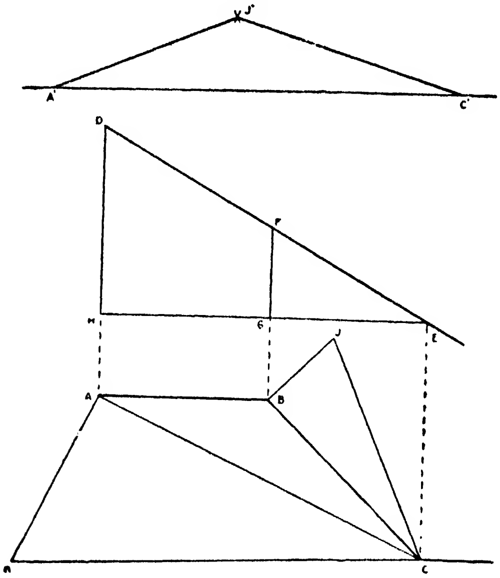


Fig. 61

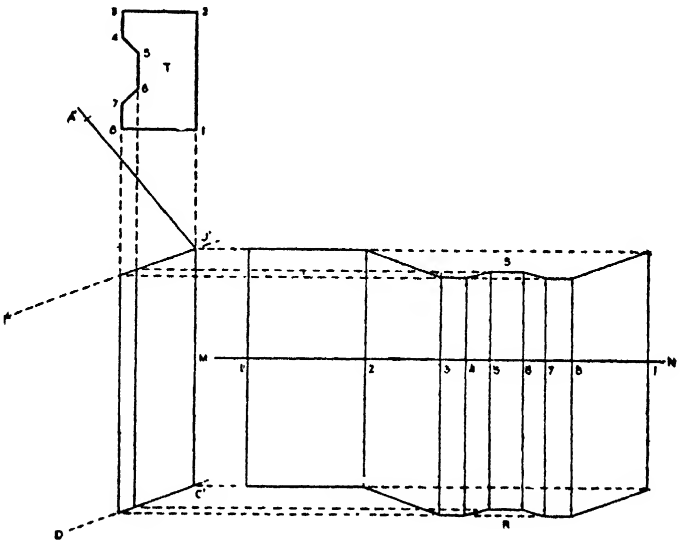


Fig. 62

To find the true angle redraw wall line A, B, C in plan and line of inclination of leader in elevation D, E, like Fig. 61. Project lines from plan to elevation as shown by D, F, E, draw horizontal line from E; erect perpendicular lines from B and A making them equal in length to G, F and H, D. Draw any line and from a point A^1 strike an arc of the length of D, F. From A^1 on line place point C^1 so as to agree in space to K, C. From C^1 draw arc in length equal to J, C, establishing point J^1. Then will A^1, J^1, C^1 be true angle.

Place angle A^1, J^1, C^1 as shown in Fig. 62, draw profile T, and drop the points to miter line previously realized by bisecting the angle A^1, J^1, C^1, and parallel to this having drawn D, C^1, at right angle to J^1, C^1, draw a line M, N, on which place stretchout of profile T. Draw lines through these points which are intersected by

like numbered lines from miter line. This is the pattern for piece III of Fig. 58. Piece IV will have the same cut as S, while piece II will have cut R.

Should the length of piece III be so large as to preclude this process of developing, pattern may be obtained in the same graphic manner by making angle of wall in plan and elevation to convenient scale thereby finding length and miter lines of piece III, then joints can be made on line J^1, C^1 at pleasure.

PATTERN FOR A COMPOUND PANELED LEADER ELBOW

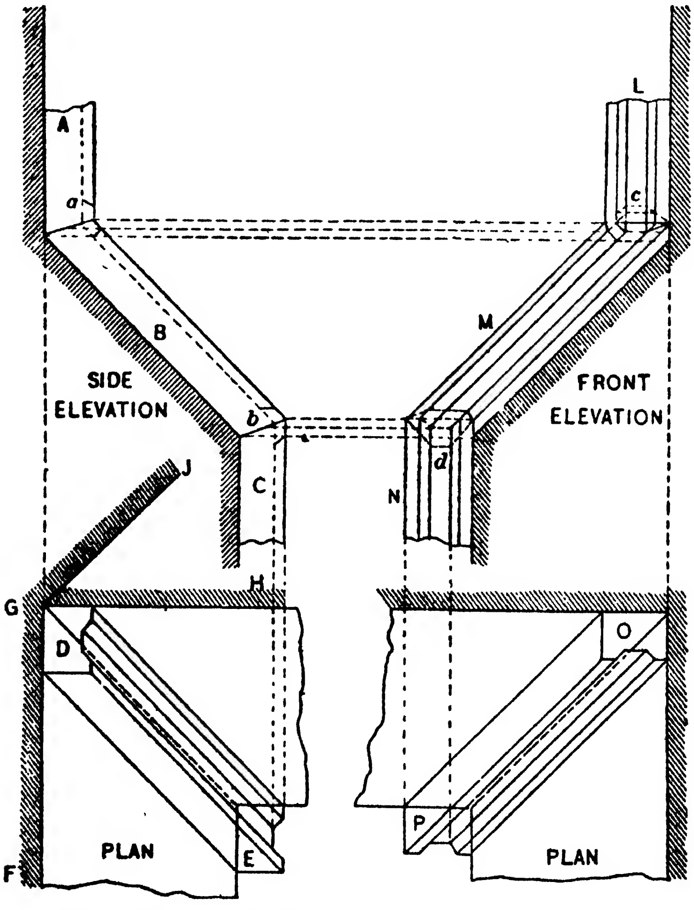


Fig. 63. Plans and Elevations of Leader Pipe Elbow

For an elbow of a rectangular paneled leader which comes down over a straight wash in an angle of the wall, and whether the leader be square or paneled, or if angle in plan be a right angle or otherwise, Fig. 63, the principles are similar whether the leader is square or paneled or whether the angle in plan is a right angle or any other angle. Referring to the sketch, Fig. 63, A B C shows the side

elevation of the paneled leader, and D E the plan of same, while F G H shows the angle of the wall, it making no difference whether the angle was square or as shown by F G J, the principles being alike in the development of the patterns. L M N is the front view, shown in plan by O P. *a* and *b* show the section of the panel miters in side, while the dotted lines *c* and *d* show the panel miters in front. When developing the patterns, the front elevation and plan are not required, only the side elevation, as shown in Fig. 64, in which A B C D is the side elevation of the vertical wall and wash and E F G H I J the plan of same. K and K^1 show the sections in plan of the vertical paneled leader, numbered from 1 to 8 in both views. Draw diagonals to points of similar numbers, which will represent the plan view of the leader crossing the wash, as shown in elevation by C B L M N O P R, the line of the sunk panel being shown by T U V W, the width of the raking pipe S being equal to the sides of the vertical pipes, or can be made any desired width.

The first patterns to be developed are those of the paneled face miters shown in front elevation in Fig. 63 by *c* and *d* and in section in side elevation in Fig. 64 by *a b c d e* and *f h i j k*. As the points *a e f* and *k* lie directly in the sink of the panel, project these points into the plan, parallel to A B, thus locating the points *a a*, *e e*, *f f* and *k k* in their proper position. In similar manner, from points *b c d* and *h i j* in side elevation drop lines parallel to A B, intersecting similiar lines in plan, as shown by *b b*, *c c*, *d d*, *h h*, *i i* and *j j*, thus producing the miter lines in plan, shown by the dotted lines.

For the pattern of the panel for the upper angle take the stretchout of *a b c d e* in side elevation and place it on the line L^1 M^1, in plan at right angles to *c c*, as shown by the small letters on L^1 M^1. Through these points and at right angles to L^1 M^1 draw lines, as shown, which intersect with lines drawn from points having similar letters at right angles to *c c* in plan. Trace a line through points thus obtained; then will N^1 O^1 be the pattern for the miter for the upper angle.

In similar manner, at right angles to *i i* in plan draw the line P^1 R^1, upon which place the stretchout of *f h i j k* in side elevation, as shown by similar letters on P^1 R^1. Through these small letters and at right angles to P^1 R^1 draw lines, which intersect with lines drawn at right angles to *i i* from similar lettered points. Trace a line through points thus obtained, as shown by S^1 T^1, which will be the panel miter for the lower angle V O in side elevation. Before obtaining the pattern for the raking pipe B N O C in side elevation it will be necessary to construct a diagonal elevation, also the true profile of the raking pipe, for which proceed as follows: At right angles to A B in side elevation draw any line, as Y Z. In similar manner, parallel to the diagonal line F I in plan draw the line Y^1 Z^1. At right

angles to F I in plan and from points 1 to 8 in both profiles, K and K', carry lines upward indefinitely, as shown. Now, measuring in each instance from the line Y Z in side elevation, take the hights to where the various points drawn from the profile K in plan intersect the miter line B N in elevation, and place them on lines having similar numbers, drawn from the profile K to the diagonal elevation, always measuring from the line Y^1 Z^1, thus resulting, when a line is traced through these intersections, in the miter line A^1 B^1. In similar manner, measuring from the line Y Z in side elevation, take the hights to where the various lines drawn from the profile K^1 in plan intersect the miter line C O in elevation, and place them on lines having similar numbers drawn from the profile K^1 to the diagonal elevation, in every instance measuring from the line Y^1 Z^1, and resulting in the miter line D^1 C^1. Connect points having similar numbers in the miter lines A^1 B^1 and C^1 D^1, as shown, which represents the diagonal elevation of the raking pipe. For the true section in the raking pipe draw any line at right angles to the diagonal lines in plan, as shown by E^1 F^1, establishing E^1 on the line 8 8. (This point could be established on any numbered line desired.) In similar manner, at right angles to the line of the diagonal elevation drawn any line, as H^1 J^1, establishing the point E^2 upon the line 8 8, because the point E^1 was established upon the line 8 8 in plan. Now, measuring in each instance from the point E^1 in plan, take the various distances to lines 7 7, 6 6, 5 5, 4 4, 3 3, 2 2 and 1 1, and place these distances, measuring in each instance from the line H^1 J^1 in diagonal elevation, upon lines having similar numbers. A line traced through these points of intersections, as shown by K^2, will be the true section through the raking leader.

For the pattern for the raking pipe proceed as shown in Fig. 65, in which A B C D, with the miter lines and numbers thereon, is a reproduction of similar letters, miter lines and numbers shown in the diagonal elevation in Fig 64, excepting that the line A D in Fig. 65 is placed vertically. At right angles to A D draw the line E F, upon which place the stretchout of the profile K^2 in diagonal elevation in Fig. 64, as shown by the small figures 1 to 1 on the line E F in Fig. 65. At right angles to E F and through the small figures draw lines, as shown, which intersect with lines drawn from similar numbered points on the miter lines A B and C D, at right angles to A D. A line traced through points thus obtained, as shown by G H I J, will be the pattern for the raking pipe.

For the pattern for the vertical pipe, shown by M N B L in side elevation in Fig. 64, take a tracing of same and place it as shown by M N B L in Fig. 66. At right angles to M N draw the line C D, upon which place the stretchout of either

of the profiles K or K[1] in plan in Fig. 64, as shown by the small figures 1 to 1 on C D in Fig. 66. Through these small figures and at right angles to C D draw lines,

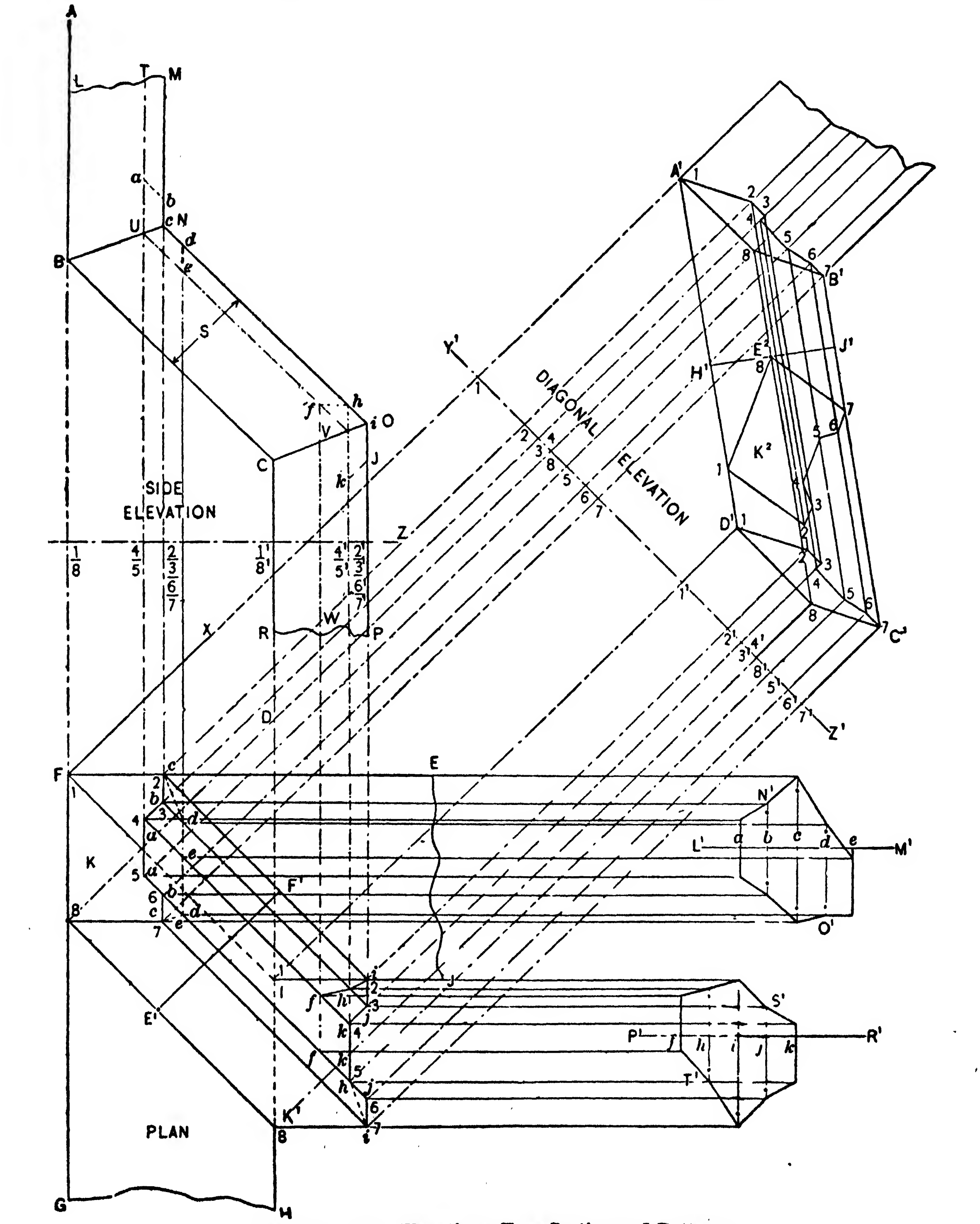


Fig. 64. Plan, Elevations, True Section and Patterns

which intersect with lines drawn at right angles to M N from similar numbered intersections on B N. A line traced through points thus obtained, as shown by E F G H, will be the pattern for the upper vertical pipe of the elbow, while the

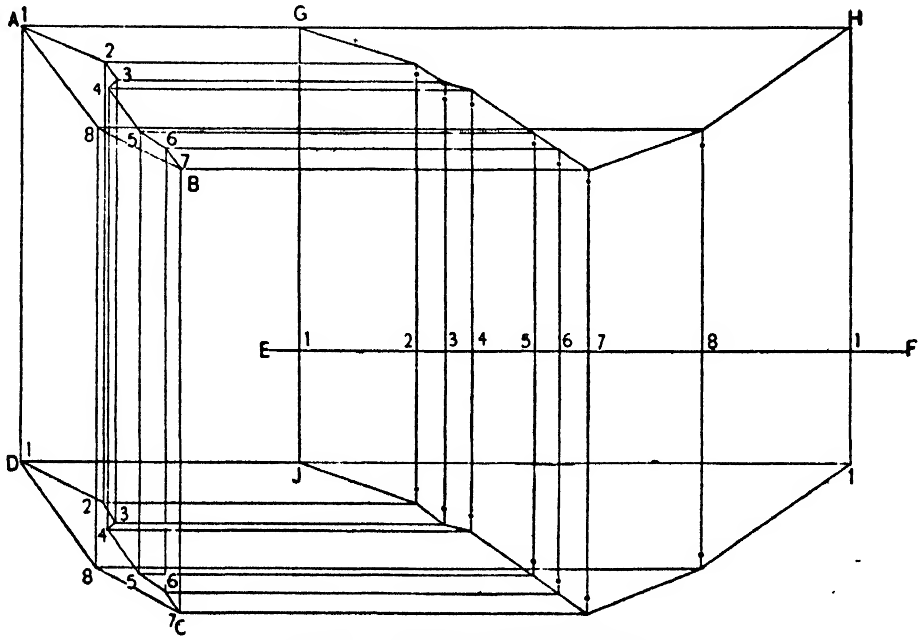


Fig. 65. Pattern for Raking Pipe

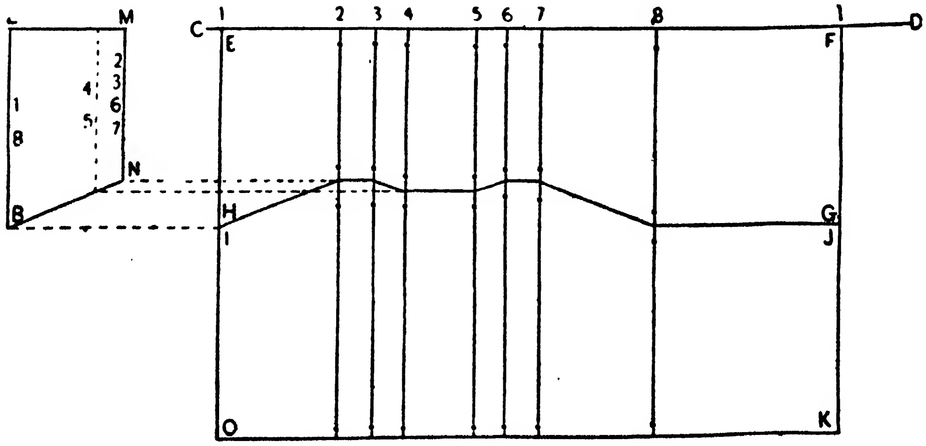


Fig. 66. Patterns for Vertical Pipes

reverse cut, or that portion shown by I J K O, will be the pattern for the lower vertical pipe.

If it were not required to have miter lines, when viewed in front elevation, horizontal the process of raking profile for diagonal piece would not be necessary, as then given profile would prevail throughout. The method of cutting pattern is described in the next article.

PANELED LEADER ELBOW HAVING DOUBLE OFFSET

The remark is frequently heard that some pattern articles are too complicated to clearly exemplify the method under consideration; there are more lines to confuse and more work to be done than is always necessary. It must be remembered, however, that such articles are essentially didactic in their purport, and to make the problems clear it is important that every step be shown which requires more lines in the diagram, and an extended text, than would be used by a draftsman, thoroughly drilled in laying out work, when cutting patterns for actual work.

In this problem it will be explained how a pattern is laid out with the idea of eliminating all possible lines. This is the method adopted by a draftsman that has cutters under him so well trained in their work that they can cut the material from just the data as here given.

This problem is for a paneled leader elbow with a double offset and it is specified that the given profile be maintained in all three of the parts thereby having the same area throughout, Fig. 67. An elevation is drawn with the offset required when viewed in elevation. In its correct position and as a plan the profile D is drawn and E 7, to represent the offset in plan.

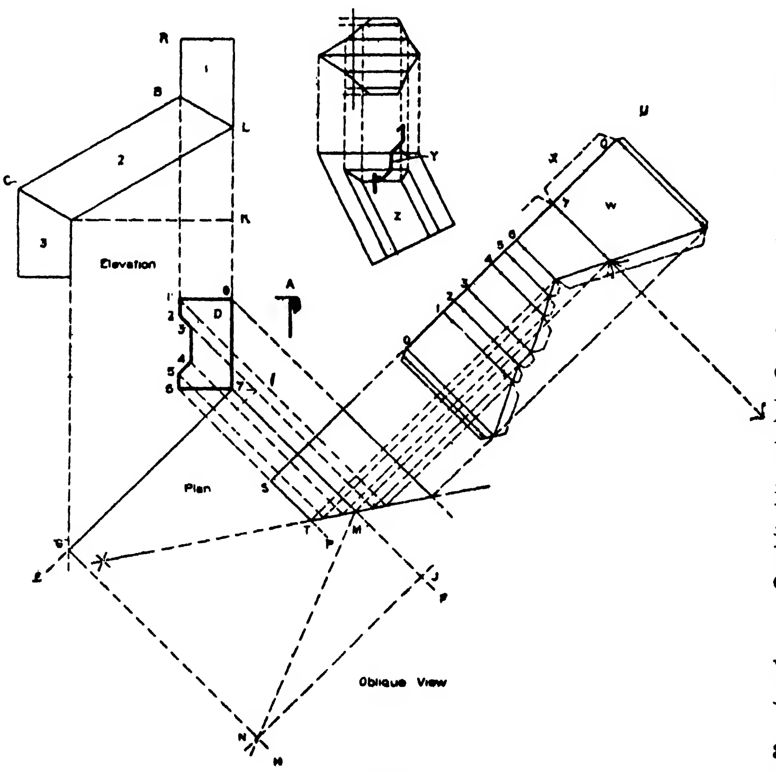


Fig. 67

For a shop drawing the profile D would be first drawn in lead pencil then on the inside of the lines a colored line would be drawn, likewise letters, etc., would be colored. This makes the important parts of the drawing distinct and of course conspicuous.

To obtain the patterns we must have an oblique view so lines 7 F and G H, are drawn indefinitely and at right angle to E 7, as

shown. Locate at pleasure point J, on line 7 F. Take the hight K L, of the elevation and from J, place this hight on line 7 F, as J M. Perpendicular to 7 F, from J, draw a line to G, H, and at the intersection N, connect with M, as shown.

Bisect the angle 7 M N. This bisecting line is the miter line. Drop lines parallel to 7 F, from the numbered points of the profile to the miter line. On line 6 P, place the space B R, of the elevation which will be S T.

At right angle to the lines as 7 F, draw a line as S U, on which step the stretch-out of profile D. From these points and perpendicular to S U, draw lines and intersect with lines from like numbers on the miter line. This will be the miter cut, for all three parts.

The drawing is taken from the board and to help the man who cuts the material the draftsman makes various notes and perhaps freehand sketches.

It is obvious that W, is full pattern for part 1. And for part 2, he writes a note on the drawing and tells cutter to move miter cut along the line of the arrows on 7, the distance N M, of the oblique view.

For piece 3 he states that the pattern W, is to be reversed, same as we would change an outside miter to an inside miter. Also instructs cutter to allow laps as shown dotted at X, for piece 3, and reminds that laps for the miter cut as shown are to be allowed on those pieces so as to have the joint with the flow of the water. He calls attention to the manner of making the seams at A.

It is now the cutter's duty to see that material is marked as to leave no doubt in the mind of the brake hand how to bend the pieces. For it is very easy to bend stuff of this nature inside out thereby having the offset the opposite to what is required.

If panel heads are called for at C and B, then for the pattern we draw a duplicate of that part of the pattern where the letter W is and place it as Z. A section is drawn, which with the exception that it is doubled, is similar to 1 2 3 of profile D. The cutting of pattern should be self-evident from the drawing.

As elbow would be soldered together before putting on the heads and as it requires considerable work to find the true angle of Y, the draftsman just calls attention to the fact that the section shown is for B, and for C, the angle would be reversed. This angle is generally bent equal to B and C, which is almost the true angle.

ALLOWING LAPS ON PATTERNS

It is the usual practice for wiring to add to the hight of pattern three times the thickness of the wire. For simple soldered seams, sufficient lap on one side;

outside the net pattern line is all that is required. For riveted joints one-half the seam is allowed on both sides of pattern and rivet holes punched on net lines of patterns.

For grooved seams one and one-half of what seam will take up is allowed on both sides of patterns.

For notching cut just a little past the net line of pattern.

POINTS ON CONDUCTORS, ROOF CONNECTION, ETC.

Conductors, of course, are very important factors in roof drainage. There are various kinds and constructions as well as methods of using and securing them in position. The type of the conductor and the method of using in gutters are governed largely by climatic conditions. A conductor that will work satisfactorily in warm climates would not answer in cold climates, because of the presence of ice. In cold climates conductors should be located inside the building wherever possible, thus being generally in a temperature above freezing point, which keeps them free of ice. Inside conductors must, of course, be made of more durable material than is necessary to use in outside conductors, as a break or leak will cause much more damage in the building than when placed on the outside.

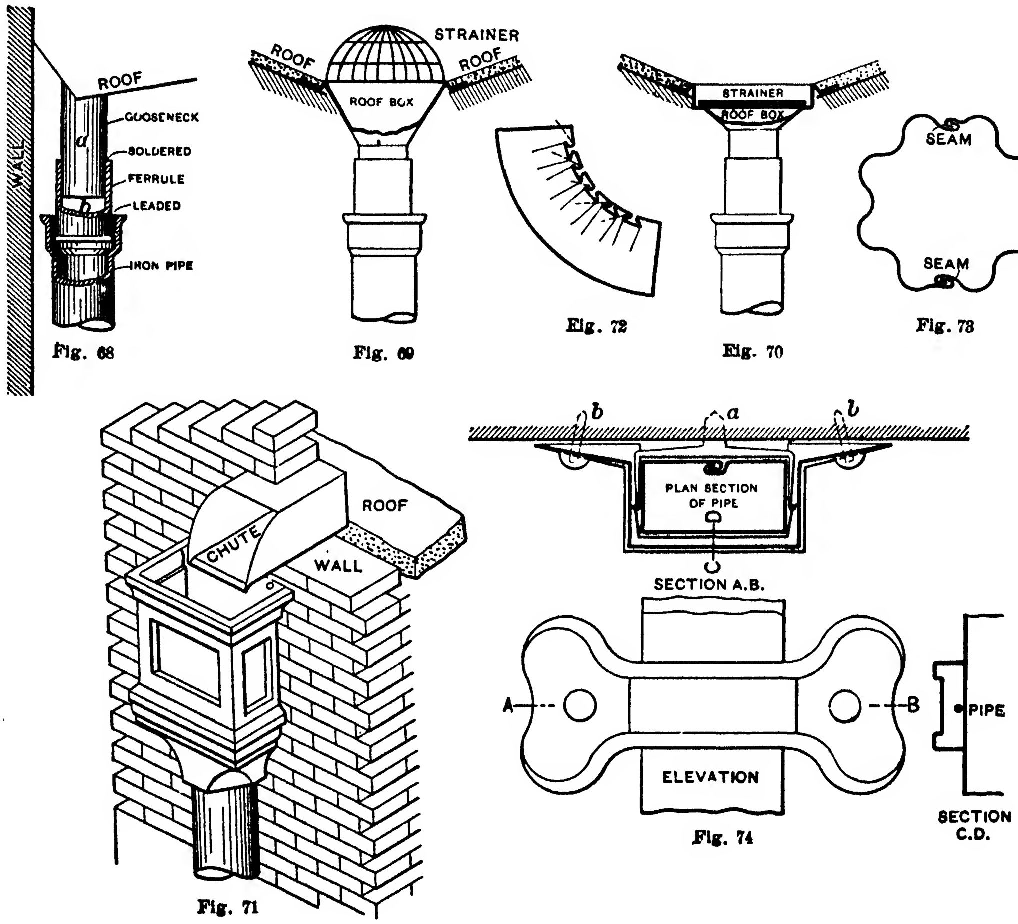
Where there is any probability of water freezing in a conductor it should be made corrugated, or of some other expansive construction, as, otherwise, the expansion of the ice will break the seam. "Goosenecks," or the short pieces connecting the conductor with the gutter or roof box, should be made of pliable and ductile material, such as lead or copper, in order that it may be easily bent to the proper shape, and be expansive in case of being filled with ice. Lead and copper also have better soldering qualities than any other material, and as the connection of the gooseneck to the gutter, and, in case of inside conductors, to the conductor, is made with solder, this is a very important consideration.

A good method of connecting an inside conductor with the gutter is shown in Fig. 68. It will be seen that the lead gooseneck, or outlet, *a*, is securely soldered to a brass or tinned wrought iron ferrule, *b*, which, in turn, is leaded into the hub of the cast or wrought iron conductor, it being advisable to use either cast or wrought iron pipe in all inside conductors.

The conductor should, of course, be connected with the sewer and should be trapped, as otherwise it would simply be a flue for the passage of foul gases from

the sewer, and as it is often the case that there are adjacent occupied buildings with windows higher than some of the surrounding roofs, it is very important that foul gas be prevented from entering the conductors. This gas is also corrosive; therefore, a trapped conductor will prove more durable than an untrapped one on this account.

All conductors should be provided with strainers at the top, in order to pre-



Points on Conductors

vent the entrance of birds, leaves and debris that would obstruct the pipe. There are various methods of constructing and using these strainers. The type shown in Fig. 69 can be used in any conductors, but in roof boxes the type shown in Fig. 70 is preferable, as it will be less likely to become displaced. All strainers should be easily removable, for the purpose of cleaning. Conductor heads should also be covered with wire netting, not only to keep out debris that may be washed from the roof, but also to prevent the building of nests in them by birds during dry weather. All strainers should be made of copper or tinned iron wire.

When outside conductors are used to drain a roof they should be connected by means of a chute through a parapet wall, as indicated in Fig. 71, with conductor heads, which are nothing more than ornamental funnels, or boxes, for receiving the water from the roof chute or gooseneck. The advantage in using conductor heads is that if the conductor should become obstructed the water will not back up and flood the roof, but will simply overflow from the conductor head, leaving the roof chute or gooseneck clear. The design of conductor heads is a matter of fancy, the only requisite being that they have sufficient capacity to take care of the water. Where hanging gutters are used no conductor heads are necessary, although they are often used for ornamentation only.

A very important consideration in all conductors is that they should be smooth inside, and not have any seams or projections that would be likely to catch small leaves, etc., as it will easily be a starting point for the lodgment of sufficient debris to completely close the pipe. Some forms of corrugated conductor elbows are stamped with seams or wrinkles running around the throat, as indicated in Fig. 72. Small particles or leaves can easily become lodged in these seams or wrinkles, which increases the opportunity for lodgment of other debris. As obstructions most easily occur in the bends or elbows than in any other part, it is important that such elbows should not be used. Corrugated elbows which are made in two sections, have longitudinal seams along the throat and back, as indicated in Fig. 73, are to be had, and should be used in preference to those constructed like Fig. 72.

There is a practice in vogue in New England of using a conductor of larger diameter than the gooseneck or outlet to which it is connected, the idea being to allow for a coating of ice, which may form inside the conductor. There is no harm in this practice if the gooseneck is always made of ample diameter to conduct the large volume of water it may be called upon to carry off; but, unfortunately, many of the architects and sheet metal men use a conductor just large enough to receive the water and reduce the diameter of the gooseneck so as to preserve the customary difference in size between the conductor and gooseneck, overlooking the fact that the conductor cannot carry any more water than is delivered to it through the gooseneck.

Various methods of securing conductors in position are employed, most of which are too well known to need mention. However, when ornamental straps or bands are used it is generally necessary to invisibly secure the conductor independent of such bands. A method of doing this is shown in Fig. 74, in which it will be seen that an ordinary conductor hook, *a*, is driven into the wall, into which the conductor is secured. The ornamental band is then planted on this hook and

secured by nails, *b b*, driven through the band into the wall. These can be ordinary wire nails with spun half balls soldered on the heads, filling the ball entirely with solder.

It is often necessary to run conductors in a nearly horizontal position for some distance, and in such cases the supports or conductor hooks should be used much closer together than in vertical pipes. In vertical pipes the weight of the pipe and its contents is distributed among all the hooks that support the pipe throughout its entire length, and the water adds very little to the strain. In fact, it adds no weight, except what results from friction in falling through the pipe; whereas in horizontal pipes the water not only remains much longer in the conductor, but its entire weight must be carried. Hence the necessity of frequent and firm supports.

BEST WAY TO CONNECT CONDUCTOR TO ROOF GUTTER

When there is danger of the tube seam bursting in freezing weather causing leaks by the water following the frieze board back to plastered wall, run the outlet, or gooseneck, out over the roof and offset back to the wall along the outside face of the cornice. If, however, this method is not feasible or acceptable, owing to the construction of the gutter, or the appearance, the next best way is, first, to run a large tube from the gutter through and to the lower edge of the cornice, or wherever the conductor pierces the exterior face of the cornice, and then run the conductor outlet through this tube. The difference in diameters of the tube and outlet gooseneck need not be large enough to leave an unsightly opening when the conductor emerges from the cornice. A perforated end board can be soldered into the lower end of the tube, the tube being cut off and the end stop conforming to the profile of the cornice, and a hole being cut in the end board to neatly fit the conductor or gooseneck. Both the tube and the gooseneck should flange out and be well soldered to the gutter. This method provides for any leakage through the gooseneck by means of the outer tube, which, of course, would conduct any such water to the outside of the cornice and the building. Another comparatively safe method

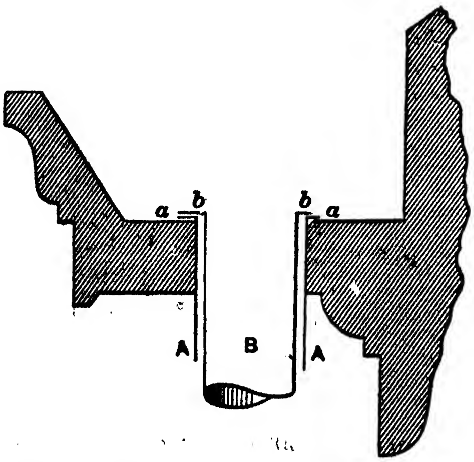


Fig. 75. Connecting Conductor to Roof Gutter

is to construct that part of the conductor or outlet that passes from the gutter to the outside of the cornice of heavy sheet lead, which can be readily formed or bent to any desired curve, and, being very soft or ductile, will allow for considerable extension caused by ice without bursting. In any case it is best to have the conductor terminate at the top in an open head, or box, for receiving the water from the gutter outlet, so that the outlet may be more accessible and less liable to be choked with ice from the conductor.

PUTTING UP CONDUCTOR PIPES

In putting up conductor pipes or leaders, where a foothold can be had on the roof, the gutter A in Fig. 76 is first put in position, flanged over on the roof B and connected with the wall flashing C. Assuming that a 5-inch pipe is required, cut a 5-inch circle through the bottom of the gutter, as shown by D, and solder into it a tube about 8 inches long and 4⅞ inches diameter, as shown at E. Let us suppose that the distance from the gutter to the ground is 50 to 60 feet. Then take three lengths of pipe, each length being 10 feet, and solder them together well, making 30 feet in one length. Now lower the rope H from the roof through the tube E to the ground, and pass it through the pipe F F by

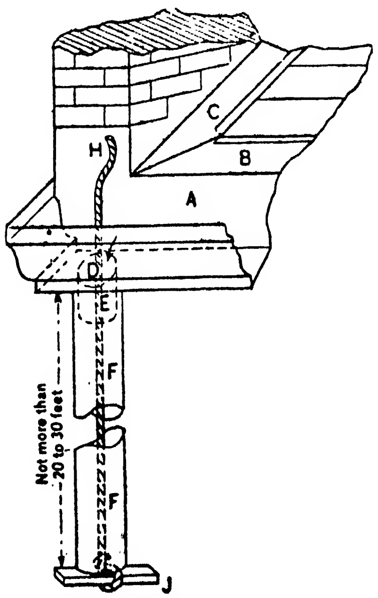


Fig. 76. Method of Putting up the Pipe

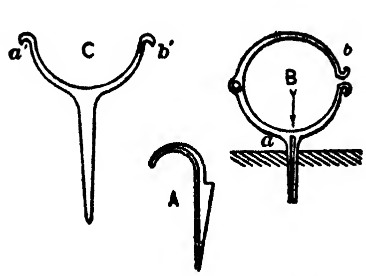


Fig. 77. Three Different Kinds of Hooks

fastening a weight to the end of the rope; then tie a strip of wood, J, to the rope, as shown.

The rope is now slowly drawn up, being careful to support the pipe in the center as it is being raised, so as to keep it from breaking, until it has reached a

vertical position; when it is drawn up tight against the bottom of the gutter. Then, from a nearby window, ladder, or sitting scaffold, the leader hook A in Fig. 77 is used to fasten the pipe against the wall, when the rope can either be dropped through the leader in Fig. 76 or the wooden strip J unfastened and the rope drawn up. When the hinged hook B in Fig. 77 is employed the hooks must be driven into the wall before the leader is put up.

Care must be taken that each hook is directly above the one under it to keep the leader in a plumb line. This is accomplished as follows: Mark the center of the back of the tube in the gutter, as shown by the arrow in Fig. 76. From this point drop a plumb line through the tube and drive the hook B in Fig. 77 so that the line will come in line with the arrow point in hook B, being careful that all hooks project the same distance (a) from the wall line. This being done, the leader is placed in position, the front half of the hook closed, and the two small clasps fastened with wire and plyers at b.

The same instructions apply to the hook C, to which, however, the leader is fastened by hooking a wire at a', passing it around the front of the leader and fastening at b'. In driving these hooks a ladder or sitting scaffold is usually employed.

MAKING SQUARE LEADERS

(On Hand Brake)

Square leaders are made as per Figs. 78 and 79, seldom if ever riveted. Experience has taught that while Fig. 78 has the disadvantage of a seam at the corner it can be bent with greater ease than Fig. 79. Also can be seamed on most any bar of suitable length that has a straight edge, whereas Fig. 79 requires a bar with a groove cut in it. The method of making Fig. 78 is:

Cut sheets to required girth (and length of brake). Dot off for bends and notch as shown in Fig. 80. To bend start at No. 5 of Fig. 78 with 4, 3, 2, 1 in brake, Fig. 81, and so on as per Figs. 82 to 85. Leader is now placed on bench, Fig. 86, and lock forced together beginning at one end and then squeezed, as Fig. 87.

Lock is double seamed on a bar of iron as shown by Figs. 88 and 89, or better still by Fig. 90, which shows the bar on two horses.

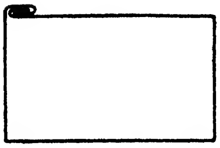


Fig. 78

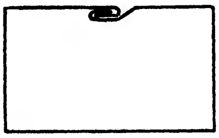


Fig. 79

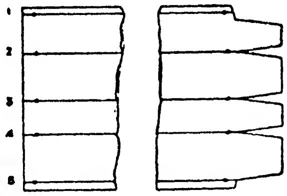


Fig. 80

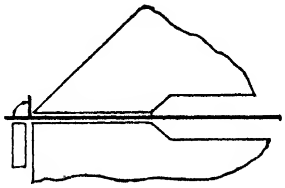


Fig. 81

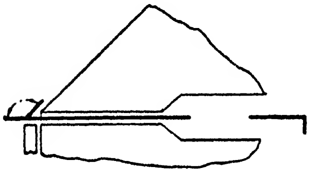


Fig. 82

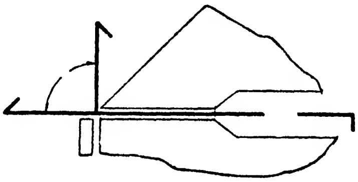


Fig. 83

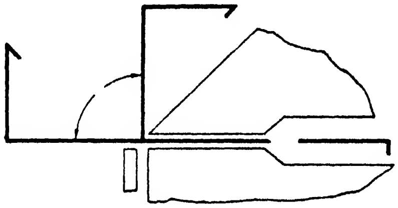


Fig. 84

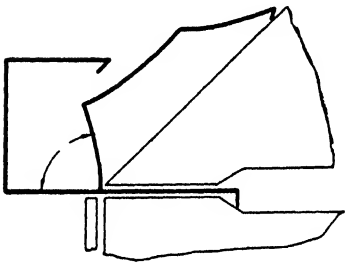


Fig. 85

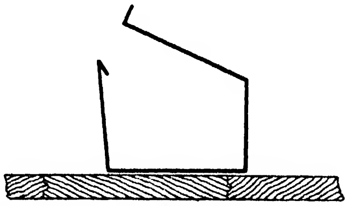


Fig. 86

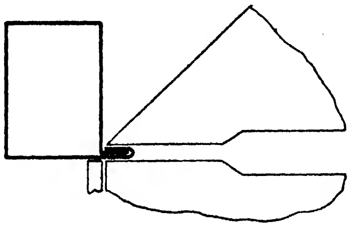


Fig. 87

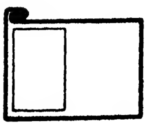


Fig. 88

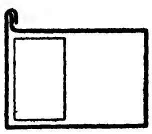


Fig. 89

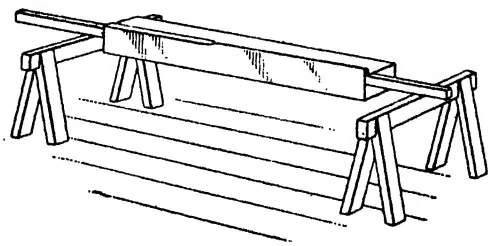


Fig. 90

MAKING CONDUCTOR PIPE BY MODERN MACHINERY

The development of conductor pipe and eaves trough machinery, although gradual, has been progressive in the line of minimizing labor and increasing the strength of the section of the pipe. Modern machines when operated by a well trained force of men, usually six in number are capable of turning out from 16,000 to 20,000 ft. of ordinary size conductor pipe in a day. In the manufacture of eaves trough, especially the slip joint pattern, a force of four men can, it is found, turn out in the neighborhood of 25,000 ft. per day. The growing use of power machines among smaller sheet metal shops emphasizes the fact that machines of this kind may be advantageously installed in many shops to make conductor pipe and eaves trough for territory contiguous to these establishments. The freight rate question has an important bearing on the subject. It was not long ago that the Freight Classification Committee made an arbitrary rule about the nesting of conductor pipe, which required unnested pipe to pay a higher freight rate than formerly, and, with the general trend in this direction, the freight rate question may become a still more important one.

The machinery equipment is not as extensive as might be supposed. In the first place, power squaring shears are now an adjunct of many establishments, and large ones are frequently used. In the manufacture of conductor pipe and eaves trough one 11 ft. long is essential, although if conductor pipe only is to be made one capable of taking a 10-ft. sheet would be sufficient. The greater length required for the eaves trough is made necessary by the fold for the slip joint. Operation of the squaring shears is of course familiar to sheet metal workers. The power variety, is designed to cut heavy metal rapidly. In operation treadles at either end of the machine are simply pressed, the same as a foot power machine, the clutch is thrown in and the cutting shear descends.

The second is an edging or folding machine. This machine edges the sheet. This is one of several varieties performing this kind of work. In this case the sheet is slipped into a slot, the width of which is made to vary for different locks, and the edge is turned. The sheet can be readily pulled out and drawn back and set for the second operation, which is in the opposite direction, as is well known in making conductor pipe or stove pipe.

The operations thus far give a rectangular sheet having on either end an edge turned. The next operation is to make the sheet round. This was formerly done

on a three-roll forming machine. Modern machinery, however, makes use of special mandrels. In operation the edge of the turned sheet is inserted in the slot along the top of the mandrel, and the mandrel frame locked, so that there is little play when the crank, shown in this instance at the right, is turned and the sheet is formed on the roller into shape. This machine is locked by means of foot treadles. After the sheet has been made round on this machine it is pushed off, and can be quickly snapped together while lying on a flat surface, usually on the front plate of the machine.

The conductor pipe has now arrived at the stage of having a round shape. Several machines are on the market for the finishing operation. In one of them the pipe is pushed onto a mandrel and the mandrel drawn between several sets of rollers, one of which grooves the seam, another set making the pipe perfectly round, while a third set does the corrugating. Of course several sets of mandrels and rollers are required in this machine. Other forms of machines make use of a mandrel swinging from one end, the operation being that the mandrel is first swung out of the head allowing the pipe to be pushed on. Only the end is inserted on the mandrel, when an endless chain draws it into position and the mandrel is then swung back, the carriage passing over it, moving from right to left. This carriage contains in the head a groover for grooving the seam, and following that is a set of wheels and dies which make the corrugations. Machines of this character make round pipe or corrugated pipe or square corrugated pipe, the only difficulty being that square corrugated pipe of No. 26 iron and heavier are usually formed into shape.

In actual practice these machines can be operated more economically when set in rotation, so that the operation is continuous—that is, the sheet being taken from the squaring shears to the folding machine, passed onto the roll formers, and finally to the seaming and corrugating machines.

In the manufacture of eaves trough special machines must be adopted, such as slip joint machine, for cutting the edge and folding the locks. The operations are somewhat similar except that the sheet is first squared and then the lock formed on the end after it has been properly notched, when it is put in the forming machine with a proper mandrel and turned into a half round shape. Afterward a special machine is used for putting the bead on the entire length at one operation. These machines sometimes have facilities for making four different size beads in one mandrel.

An impression may have been gained from reading the foregoing that eaves trough and conductor pipe machinery is never made for longer lengths than 10 ft. Such is not the case, however, special machines for longer lengths having been

built to order. It was not so many years ago that pipe of 3 ft. was in general use, and this seems to be the case in parts of New York City to-day. It may be that the more general use of machinery with longer lengths of pipe will be made so as to minimize rusting, and, moreover, the fewer joints there are in any section of pipe the easier it is to erect it.

PROTECTING CONDUCTOR PIPES FROM FREEZING

In order to prevent the possibility of conductor pipes freezing this scheme has been employed. Inclose it, as shown in Fig. 92, in a corrugated galvanized iron pipe so arranged as to provide a dead air space with stays to keep the water pipe central. This corrugated piping is in turn covered with hair felt one (1) inch thick and to protect felt from weather the piping is covered with another of sheet metal; affording still another covering to prevent freezing of drain pipe.

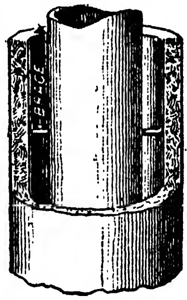


Fig. 92. Method of Protecting a Conductor Pipe

The manner of erecting is to connect lengths into one manageable length, of both drain pipe, (if of sheet metal) and corrugated pipe. The braces can be attached (soldered or riveted) to either pipe Then these two are slid one into the other and erected. Felt wrapped around and secured with sheet metal straps and outer casing is put on in short lengths. This outer casing is in two parts—that is, it has two vertical seams which are of the standing seam kind to permit ease of application.

Felt and outer casing will be cut to fit around the supporting hooks, and outer casing is held in place by means of these hooks.

Should drain pipe be of cast iron or screw pipe, which of course is erected first, then corrugated pipe must be made with two vertical seams same as outer casing.

BUILDING COLUMNS TO CARRY ROOF DRAINAGE

The building columns of a large machine shop are made to carry the drainage from the roof they support. The arrangement is shown in the accompanying engraving. As indicated, the roof is of the saw-tooth pattern—that is, of such a form that a section through it gives a conformation of lines not unlike the teeth of a saw. In its usual form, as well known, it consists of a vertical rise, which is glazed and faces usually toward the north, and of an inclined portion which pitches from the top of one vertical rise portion to the bottom of the next vertical rise portion. One of the main objects of such a roof is, of course, that a large area can be covered by simple systems of roof trusses carried in turn by relatively light columns, with an abundance of light, which by reason of the northern exposure of the glass por-

tions does not include direct illumination from the sun with the added heat transmitted by radiation from that source. The building is one story in hight and 320 × 126 feet in plan. It is divided into bays 16 feet 9 inches wide from center to center of the lines of columns, with the columns spaced 20 feet 10 inches on centers. The general construction and sizes of these saw-teeth have proved very satisfactory. The gutters between are of ample size; the window sills are 16 inches above the highest point of gutter, to allow for heavy falls of snow, and the sashes are 7 feet high. The gutters empty into copper sumps, and are connected to the interior cast iron columns. These latter are coated on the inside with asphaltum and serve as conductors. Below the sash of the saw-teeth roofs are provided small condensation gutters of copper, which connect into every column. Every other sash in the saw-teeth is arranged to swing on center pivots. These are operated by geared ventilating apparatus.

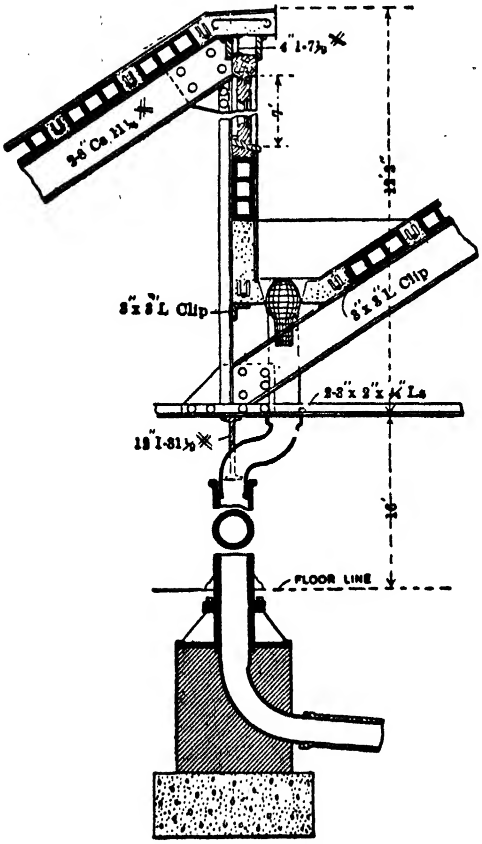


Fig. 98. Building Column to Carry Roof Drainage

The building, it may be added, is constructed of non-combustible material throughout, with brick walls, faced on the outside with a standard size paving brick, and on the inside in factory portions with sand and lime bricks, enameled five coats and presenting the appearance of enameled bricks. The floor and roof construction throughout is of hollow tile and reinforced concrete. The roofs are covered with standard magnesia roof covering, with which also the gutters are lined. The building is heated with hot water. Pipe coils suspended from walls below the windows and from base of saw-tooth directly under sash are used. The latter arrangement materially assists in keeping the gutters between the roofs free from ice and snow. The mains supplying the coils in machine shop are run just above and supported on the I-beam grillage which supports the shafting and the roof construction. No pitch of pipes being necessary in the form of heating adopted this permits of a very neat arrangement of piping.

THAWING FROZEN CONDUCTORS

Apparently there is no permanent remedy for this except to have drain pipes run inside of building, but this is not practical for the average type of building construction; so it is usual to resort to liberal doses of hot water and rock salt.

Of course if plenty of steam is available, leaders could be thawed by forcing a hose connected with the steam supply into leader. As it is self-evident that it is necessary to start from the bottom of leader and should leader be connected to soil pipe a hole must be cut in the leader; therefore it is suggested that if there is a frequent occurrence of freezing, a permanent opening be made at the bottom and in a long leader at accessible intervals to permit insertion of the hose (or hot water and rock salt). This opening should be in the nature of a gate or as an offshoot similar to Fig. 94.

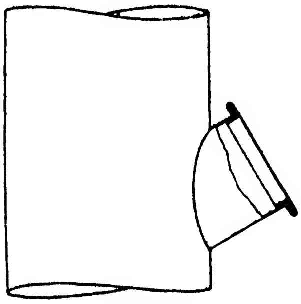


Fig. 94

There are several boilers on the market which are especially made for thawing service pipes. The same apparatus that is used for thawing frozen service pipes is used for thawing leaders where a block of tin pipe is not used, it being only necessary to attach the hose carrying the steam to a stout wire and to push it up the leader. The following is a description of a homemade apparatus, Fig. 95, and the method of using it: The machine consists of an ordinary 15-gallon expansion tank resting horizontally on legs made from the band iron taken from bundles of sheet iron. In one of the openings intended for the water gauge there is a short nipple and a ½-inch cross. On one side of this cross there is an ordinary steam gauge to register 35 pounds, and on the other side is an ordinary safety valve, set to blow off at 30 pounds, for safety. On the top of the cross is a nipple and a gate valve to let out the air when filling the boiler with water. In the other water gauge opening there is a ½-inch nipple and a ½ × ¼-inch reducing elbow, with a short nipple and a swinging check valve, then another nipple and a ¼-inch gate valve. This is where the steam supply is taken from. In one end of the boiler there is an elbow and a short

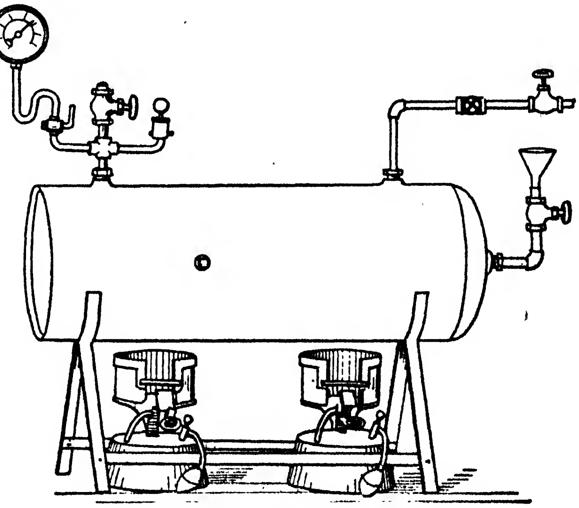


Fig. 95. Thawing Frozen Pipes

nipple and a ½-inch gate valve with a tin funnel on the top to fill the boiler with water. The other openings are plugged.

Put in the boiler two pails of water—hot when you can get it. Place two good gasoline furnaces under the boiler and let the steam run up to 25 pounds pressure, when the apparatus is ready for work. If the water in the boiler gets low, which can be told by the steam suddenly dropping off, exhaust the steam in the boiler into a bucket of water and then empty the water into the boiler. This will warm the water that is to enter the boiler and aid in getting steam up again quickly.

When using it outside of a building use three furnaces and a sheet iron jacket to keep off the wind. Charcoal fire pots could be used instead of gasoline furnaces. This machine is cheap to rig up and successful in operation. One was used for six winters and it is good yet. You cannot, however, do much work with it under 20 pounds steam pressure.

Fig. 96 illustrates a smaller device which has been used with satisfactory results. It consists of an ordinary gas fire pot with a galvanized iron can of larger or smaller size, according to the necessity of the case. The top of this can is provided with two outlets, both made from small pieces of galvanized iron pipe securely soldered into place. The one which stands vertically from the top of the can has a small globe valve on it just above a T arranged to receive a small safety valve. Above the globe valve a small funnel is soldered.

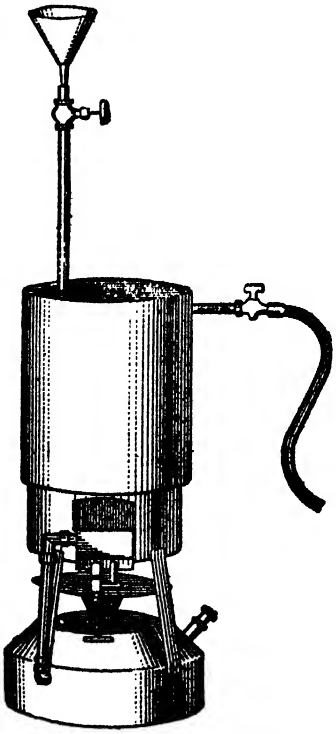


Fig. 96. Thawing Pumps

From the side of the boiler another small pipe is connected with another small valve, or petcock, arranged to receive a rubber hose. When this boiler is heated and a sufficient steam pressure is generated the hose is inserted into the pump, and from its flexible character, with the pressure behind, it readily finds its way to the ice, and a very few minutes is all that is necessary in the majority of instances to remove the ice, even though it be as much as 60 feet distant from the little boiler. The fact that every shop has its gasoline soldering furnace and can easily make a little boiler and that the apparatus when needed can be easily carried to the place where its services are needed render this method of thawing widely available. It might be stated that electricity has been employed to melt the ice in pipes. A discussion of this

and likewise the necessary amount of steam required for the aforesaid methods, is too technical for the scope of these series which are essentially related to the practical application of pattern cutting.

CAPACITY OF CONDUCTOR PIPES

The capacity of conductor pipes, or down spouts, as they are called in some sections of the country, is of more than passing interest. The size of the conductor pipe necessary depends on several conditions. The maximum amount of rain fall in a given period is of primary importance. Fortunately, however, considerable information is at hand regarding that subject through reports of the Government Weather Bureau, some of the statistics being especially complete.

It is generally assumed in computing the areas for sewers that the rainfall rarely exceeds 2 in. per hour, but we have well authenticated data there were two storms in Connecticut and Rhode Island where the maximum hourly rate was 4.5 in., and one storm in Maryland where the rate was 4.6 in. In California, likewise, a rate of 8.7 in. is recorded. While this is a considerable variation a due allowance must be made for the fact that during short periods in violent thunder storms the rate may even exceed this maximum, but as a general condition in Northern States east of the Rocky Mountains a rate of 8 in. per hour will answer for practically all purposes. Should the rate exceed this for a short time the constructions of the gutter and the conductor will undoubtedly permit of discharging under a larger head than that assumed in the following computation, and, indeed, experience in a number of large structures has shown that this allowance was ample.

Considering a rate of rainfall of 8 in. per hour the total fall on each 1000 sq. ft. of area would be $1000 \times 8 \div 12 = 666.6$ cu. ft. per hour, or 0.185 cu. ft. per second. Having found the amount of rain to be taken care of it will be necessary to determine the capacity of the conductor for carrying off the water.

It is ordinarily assumed that where there is a small head the velocity is equivalent to the square root of the hight in feet multiplied by twice the acceleration of gravity in feet and this result multiplied by some constant. Numerous determinations have been made to find the value for this constant in tubes of all sorts and conditions, and considering the tube under consideration is 6 in. long, with a head of water 6 in. above it, which would be the case in some instances, the constant would be 0.62. Completing the indicated operation, $0.62 \sqrt{2 \times 32.2 \times 1}$, a velocity of 5.08 ft. per second is found, which, however, would be materially exceeded

should there be a higher head above the outlet. This velocity of the discharge in feet per second is used in working up the accompanying table.

It will next be necessary to determine the area of such size pipes as are ordinarily used for conductors, as well as the discharge. The volume of discharge being found by multiplying the area of the conductor in feet by its velocity in feet per second, 5.08, which gives the discharge in cubic feet per second. The areas of various size conductor pipes in general use in square inches and decimals of a square foot, as well as the volume of water discharged by them, as computed by the foregoing calculation, are shown in Table A.

To determine the pipes required for different areas it will be necessary to find

TABLE A

DISCHARGE OF SHORT TUBES IN CUBIC FEET PER SECOND

Diameter in inches	Area: Square inches	Area: Square feet	Discharge
3	7.06	0.049	0.25
4	12.56	0.086	0.44
5	19.63	0.136	0.69
6	28.27	0.196	1.
7	38.48	0.265	1.35
8	50.26	0.345	1.75
9	63.61	0.44	2.25
10	78.54	0.49	2.50

the carrying capacity of 1 sq. in. of pipe, which can be determined by dividing the discharge in cubic feet by the area of the pipe in inches, which gives 0.035 cu. ft. per second for every square inch of area. Then 0.185, the discharge in cubic feet per second from 1000 sq. ft. of surface, divided by 0.035, gives 5.25 as the area of pipe required for a roof of this size. This will require a conductor pipe 3 in. in diameter, as indicated in table B. In this table are shown the size of conductor pipe necessary to be provided for roofs of different areas, and also the maximum area which pipes of different diameters may ordinarily be expected to discharge. Conductor pipes smaller than 3 in. in diameter are not desirable, owing to their liability of becoming clogged with leaves or debris.

In the foregoing calculations it is assumed that the roof areas are of such a character and the incline so acute that the rain fall striking the surface is led to the gutters and conductor pipe in a short space of time. Should, however, the roof be of an unusual surface, say such as a slag roofing or especially flat, no doubt smaller pipes could be used with safety, but the pipes given in the following calculation are presumed to be on the safe side.

In the City of New York, building regulations recommend 1 sq. in. of conductor pipe area to 100 sq. ft. of roof surface, while it will be seen from the above tables that the allowance here given is 188 sq. ft. of roof surface to 1 sq. in. of con-

ductor pipe area. However, there are many buildings in the City of New York where this rule is greatly exceeded. On the Sloane Building, with a roof area of 18,000 to 20,000 sq. ft., and a slope of 1 in 25, the leaders give an allowance of 240 sq. ft. of surface to a square inch of opening. On several buildings in Boston the proportion is only 50 to 70 sq. ft. of roof surface to 1 sq. in. of opening.

A rule of the American Bridge Company provides 1 sq. in. of conductor pipe area to every 160 ft. of roof surface for roofs of less than 50 ft. span, and 204 ft. of area for roofs from 50 to 100 ft. in span. On practically the largest building in

TABLE B

SIZE OF CONDUCTOR PIPE FOR DIFFERENT ROOF AREAS

Roof area	Discharge in cubic ft. per second	Square inches conductor required	Diameter round pipe Inches
11,958	2.25	63.61	9
10,000	1.848	52.5	
9,449	1.75	50.26	8
9,000	1.6632	47.2	
8,000	1.4784	42.	
7,234	1.35	38.48	7
7,000	1.2136	36.7	
6,000	1.1088	31.5	
5,204	1.00	28.28	6
5,000	0.9240	26.2	
4,000	0.7392	21.	
3,690	0.69	19.63	5
3,000	0.5544	15.9	
2,363	0.44	12.56	4
2,000	0.3698	10.5	
1,227	0.25	7.06	3
1,000	0.185	5.25	
900	0.1663	4.7	
800	0.1478	4.2	
700	0.1213	3.7	
600	0.1108	3.2	
500	0.092	2.6	
400	0.074	2.1	
300	0.055	1.6	
200	0.037	1.0	
100	0.018	0.5	

New York City, whose roof area occupies approximately ¾ of an acre, and is paved with brick, there is 1 sq. in. of leader opening to every 150 sq. ft. of roof surface.

The impossibility of finding an exact solution to problems of this character and the different ideas of various architects and engineers, as shown by the foregoing variation in size, ranging from 1 in. in 70 to 1 in. in 240, is aptly illustrated. Another idea of the same subject is found in a recent article in *The Metal Worker* entitled "Capacity of House Drainage Piping," in which the following statement

is made: "If the rain and snow water from the roof has to drain through conductor pipes into the house drain, the following sizes may be applied to determine the number and size of pipes needed; also what size the drain should be increased to. One square inch of area in a conductor pipe will drain 250 sq. ft. of exposed roof surface. We will take the roof of the building considered and assume that the building has a frontage of 100 ft. by 120 ft. depth, which gives 12,000 sq. ft. of roof surface. Applying the rule, $12{,}000 \div 250 = 48$ sq. in. required in the conductor."

RECEPTACLE FOR ACID

Glass is the proper material for a receptacle for acid. Use an ink or mucilage bottle and keep it from being broken or easily upset by encasing it in sheet metal, as indicated in the accompanying Fig. 97, filling the space between the glass bottle and the metal casing with plaster of paris. The bottom is then soldered on. Lead is the best material. The second sketch of the Fig. 97 shows how to make a receptacle which, if upset, the acid cannot run out.

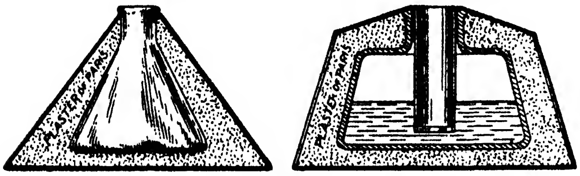


Fig. 97. Receptacles for Acid for the Tinsmith

PROTECTION OF TIN ROOFS AGAINST LIGHTNING

This is a method adopted by a prominent contractor, who says: I would suggest that if the best results are to be obtained by using a metal roof and conductors as lightning conductors it would be a good idea to run a piece of copper, say $\frac{1}{8} \times$ 1 or $1\frac{1}{2}$ inch wide, up above the ridge of the roof, probably 2 feet, riveting same to the roof and thoroughly soldering the connection so that it will be solid and secure.

A similar piece of copper should then be riveted to the lower eave of the roof and to the top of the leader, both of these points being soldered.

Near the bottom of the leader, but above the tile drain, another piece of copper of the same size should be riveted to the leader and thoroughly soldered. This copper should be at least 7 feet long, so that it can go down into the ground at least 5 feet and turn out a few inches from the building.

Providing for this a hole 4 or 5 feet square should be dug in the ground 6 feet deep. This should then be filled for about 18 inches or 2 feet with scrap iron and coke, into which the copper strap should be imbedded. The reason for doing this is to furnish a material at the bottom of the copper strap which will disseminate the lightning into the wet ground.

This is not an experiment, as the writer made just this kind of provision as protection against the lightning on a powder magazine which was built for the Government a few years ago.

On this magazine the leader and roof were of copper, and the copper strap, which extended above the ridges of the roof, were run clear down over the roof into the leader, connecting to the leader near the top, and a like strap was riveted to the leader near the bottom and run down into the ground as suggested above.

All of the leaders were connected in this way, and it is probable that this is done on all the Government magazines which have metal roofs, and there is no reason why it should not serve the purpose with any kind of a metal roof, providing the connections are well made, so that there is no chance for dirt, etc., to fill the space between and thus reduce the conductivity of the connections.

To get the best results it will be necessary to run the straps down into the ground far enough to reach into earth, which is always wet.

REGULATIONS FOR RAIN LEADERS AND GUTTERS IN WASHINGTON

Regulations covering rain leaders and gutters have been amended by the Commissioners of the District of Columbia, and as they stand to-day are in part as follows: Short connections to rain leader pipes passing through attic spaces or other parts of buildings, shall be considered a downspout and shall be constructed of lead pipe, not less than D weight, extra heavy cast iron pipe or galvanized wrought iron pipe with recessed fittings. No sheet metal leader shall be of less internal diameter than the sewer terminal provided. No eave or cornice gutter shall be of less average depth than the internal diameter of the rain leader serving it, nor less in width than twice the internal diameter of the said rain leader. In every case where the connection from the top of a rain leader is made through a parapet, mansard, or other construction, such connection shall be indirect and

made to discharge over a receiver box of proper size and design, which shall be attached to and form part of the rain leader pipe. Rain leader pipes, wherever practicable shall be vertical. The running of diagonal leaders for distances greater than 15 ft. is prohibited.

Every downspout (rain leader within a building) connection to a sewer shall be trapped with a water sealing trap placed as near as possible to the foot thereof; except, that two or more adjacent small leaders may be connected together on one trap, a small rain leader may be connected in above the trap of a large leader, or a small leader may be connected in above the trap of an area drain, or *vice versa.* A cast iron hub connection shall be provided above grade for the reception of sheet metal leader in every case, and the connecting joint shall be made by the plumber. No downspout trap shall be of less internal diameter than 3 in., but the cast iron extension to grade therefrom, for drainage areas less than 100 sq. ft. shall be 2 in. internal diameter. Every rain leader placed within the walls of a building shall be of extra heavy cast iron, or of galvanized wrought iron, and a water tight connection shall be made at the roof by means of a brass ferrule and an 8-lb. lead or 16-oz. copper extension properly joined to a roof flange of the same material which shall be flashed into the roof construction. Wrought iron leaders shall be connected and joined with recessed fittings, and together with cast iron leaders shall be amenable to general requirements for soil and waste lines and shall be tested.

STRENGTH OF SEAMS—MERIT OF PLAIN OR CORRUGATED LEADER

In the question of which is the strongest seam—locked or riveted; and which is best—corrugated or plain leader; it is agreed that any leader whose shape is such (corrugated) that when freezing occurs the additional metal contained in the corrugations, etc., will allow the pipe to expand; is preferable to plain leader which by reason of no additional material in its perimeter must resist the pressure of expanding ice at once.

There seems to be a difference of opinion relative to whether locked or riveted seams are stronger. Most shops that make their own leader generally employ rivet seams for round pipe and the lock seam for square leaders. See making leader.

GALVANIC ACTION, SEWER GAS, ROTTING OF TUBES

Speaking of why top of leaders and tubes should rot out first, it has been stated by some that experience has taught them that for some unaccountable reason the sewer gas affects the tube and top portion of the leader first. Others are of the opinion that the tube being made smaller than the leader and tapering, water is held by capillary attraction between the tube and leader causing the tube and that part of leader to rot first. Apparently there is no remedy other than to use the best material; if possible copper.

In the matter of galvanic action created by joining copper to iron—there is no danger of soil pipe being affected if a copper leader is connected, inasmuch as the soil pipe is of very heavy material and leader is caulked in either with lead, roofing cement or Portland cement preventing contact of copper with the iron. As to connecting a copper tube to galvanized iron leader it is imperative that tube be tinned entirely so, inside and out.

A SOLDERING TROUGH

In Fig. 98 is shown a wooden trough used for soldering leaders or pipes. This trough is made of $\frac{3}{4} \times 6$ inch stuff, 10 feet long, with standards fastened or nailed to the bottom, as shown by A, B and C. It is used as follows: When the pipes are all grooved or riveted together in 24, 30 or 36 inch long joints, one end of each joint is crimped, and the joints put together in one length of 10 feet. The joints are first tacked with solder on both sides, then the trough is raised a little higher on one end to allow the solder to flow when soldering. In diagram D is shown the leader E in position.

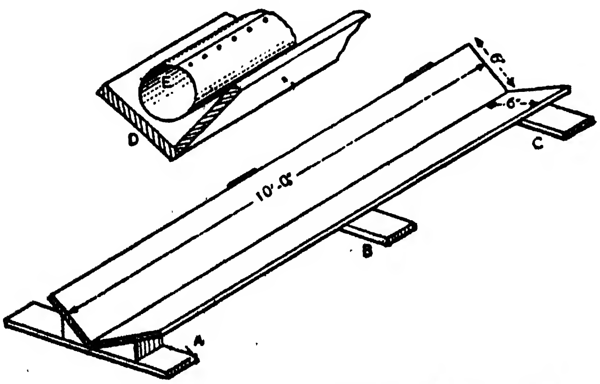


Fig. 98. Trough for Soldering Leaders or Pipes

FIRE POTS

No doubt many tinners have experienced trouble while working on new jobs by having hot coals fall out of their fire pot when taking out a soldering copper. This is very apt to occur in the ordinary fire pot shown in Fig. 99, where, as above mentioned, when taking the coppers out at A hot coals fall onto the wood sheathing, and if no precaution is taken on a windy day are apt to cause some expensive damage. This can be avoided by putting a safety pan under the soldering copper support C in Fig. 100, as shown by A, with a ledge bent around the three sides, as shown by B. Then if any hot coals should fall out they will be caught in the pan A and much danger and trouble avoided.

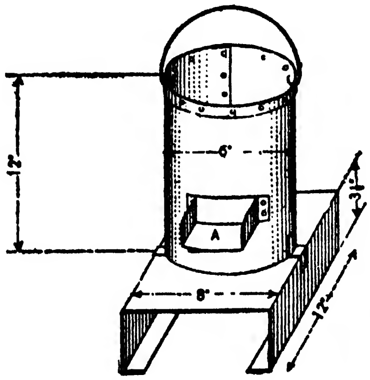


Fig. 99. The Ordinary Fire Pot

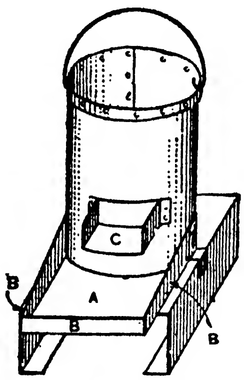


Fig. 100. Pot with Safety Pan

RAIN WATER CUT OFF

In place of the handle on the ordinary cut off, put on a bar long enough to allow a can to be hung on one end. When this can is empty, the weight on the other end of the bar will throw the valve of the cut off, so that the water running from the dusty roof would go to waste, while the small pipe connected with the main conductor would catch water and eventually fill the can on the other end of the bar, which would turn the cut off so as to throw the water, which by this time would be running clean, into the cistern. The pipe provided to fill the can should be small enough and so arranged that sufficient time will be given for the roof to be well washed and the water to be running clean before the cut off is automatically adjusted to divert the water into the cistern. In order that the cut off may be thrown back into position to send the first water from the roof to waste after the rain has stopped, the can should be provided with a small hole. This will allow the water to run out and empty the can after the rain has stopped.

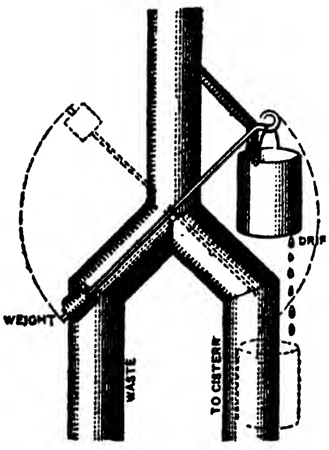


Fig. 101. Rain Water Cut Off

By this means the cut off will work automatically, though there will be some waste, which in all probability will not be objectionable. The hole in the can should not be too large, or it will take too long to fill the can to trip the cut off in the first place.

TABLE SHOWING CAPACITY OF CISTERNS, TANKS AND WELLS

	DEPTH														
Dia	5	6	7	8	9	10	11	12	13	14	15	16	18	20	Edge	Flat*
3	8	10	12	13	15	17	18	20	22	23	25	27	30	34...	38	66
3½	11	14	16	18	21	23	25	27	30	32	34	37	41	46...	45	80
4	15	18	21	24	27	30	33	36	39	42	45	48	54	60...	52	94
4½	19	23	26	30	34	38	42	45	49	53	57	60	68	76...	59	108
5	23	28	33	37	42	47	51	56	61	65	70	75	84	93...	66	123
5½	28	34	39	45	51	56	62	68	73	79	85	90	102	113...	73	137
6	34	40	47	54	60	67	74	81	87	94	101	107	121	134...	80	151
6½	39	47	55	63	71	79	87	95	102	110	118	126	142	158...	87	165
7	46	55	64	73	82	91	101	110	119	128	137	146	165	183...	94	179
7½	52	63	73	84	94	105	115	126	136	147	157	168	189	210...	101	193
8	60	72	84	95	107	119	131	143	155	167	179	191	215	239...	108	207
8½	67	81	94	108	121	135	148	162	175	189	202	216	243	270...	116	222
9	76	91	106	121	136	151	166	181	196	212	227	242	272	302...	123	236
9½	84	101	118	135	151	168	185	202	219	236	252	269	303	337...	130	250
10	93	112	131	149	168	187	205	224	242	261	280	298	336	373...	137	264
11	113	135	158	181	203	226	248	271	293	316	339	361	406	451...	151	292
12	134	161	188	215	242	269	295	322	349	376	403	430	483	537...	165	321
13	158	189	221	252	284	315	347	378	410	441	473	504	567	630...	179	349
14	183	219	256	292	329	366	402	439	475	512	548	585	658	731...	193	377
15	210	252	294	336	378	420	462	504	546	588	629	671	755	839...	207	405
16	239	286	334	382	430	477	525	573	621	668	716	764	859	955...	222	434

A round cistern 7 ft. in diameter and 8 ft. deep will hold 73 barrels of 31½ gallons. To find the dimensions of a cistern or tank holding a certain quantity, for instance, 200 barrels, look in the table for an approximate number, and the diameter will be seen to the left, and the depth above it. Thus, to hold about 200 barrels, it must be 8½ ft. in diameter and 15 ft. deep; or 9½ ft. in diameter and 12 ft. deep.

***The two right-hand columns show the number of brick required in a wall. Thus, a well 4 feet in diameter will take for *each foot in depth*, 52 brick laid on edge, or 94 brick laid flat.**

PAINTING CONDUCTOR PIPE

(On Inside)

If it is required that leaders be painted inside and out it is suggested that leader be made complete in convenient lengths—say ten feet—so that there will be as little soldering as possible to do after painting. Then with a piece of wood made for this purpose plug up one end of the length of leader, pour the paint in, plug up the other end and run paint backward and forward so as to cover whole of inside. Take out plugs and stand leader in an upright position in a pan to drain off surplus paint.

FINDING THE CENTER OF A CIRCLE

This instrument, which is illustrated herewith, can be made in any tin shop from either galvanized iron or sheet brass; the latter would probably be preferable. Two pieces of metal are cut out, as B C O and A C O, the line O P in either case being a perpendicular bisector of either A B or B C. At the points A and C a hole is punched through, and at B the two pieces are riveted so they can rotate about that point. By putting the points A, B and C on the circumference of the circle the point O or the intersection of the two straight edges will be the center of that circle. The solution of this problem may be proved geometrically from the geometrical principle that through three given points in the same plane one and only one circle may be drawn.

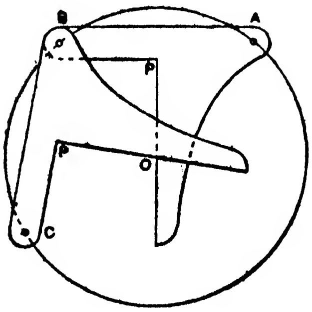


Fig. 102. Finding the Center of a Circle

MARKING FLUID FOR GALVANIZED IRON OR ZINC

Take a small bottle and partly fill it with muriatic acid, into which put a small quantity of copper filings—that is, the filings from the soldering copper, which have been filed previous to tinning. Allow it to stand a few days until the acid turns to a dark blue color, when it is ready for use. Take a piece of hard wood and point it similarly to a pencil. By dipping this into the fluid the zinc or galvanized iron can be marked with it as desired.

OFFSETTING CONDUCTOR HEAD PATTERN

To construct patterns for a conductor head with curved surfaces and offsetting under cornice to face of wall, as shown, draw the side elevation and front elevation as desired, using center points for curved surfaces, or draw free hand. Space curved line A of the side elevation equally from point 4 to 10; also space 11 and 12 as shown. Draw parallel lines through these points to line B and also to cross curved lines C and D in front elevation. Draw stretchout line E F and then transfer the points from curved line A to line E F, as 1 to 12. Draw lines from these points at right angles to line E F indefinitely, and in front elevation drop lines from points on side line D to cross proper lines in pattern; then draw curved line G through these points, completing half pattern for front. Next transfer points from back line B in side elevation to stretchout line E F; draw lines from these points at right angles to line E F; then drop points from curved line C in elevation to cross these lines in half pattern; draw line H through these points, completing half pattern for back. There are two extra bends in this pattern, shown by small circles. Next draw stretchout line I for side pattern and transfer the points from curved line C to line I as shown, drawing lines through these points as previously explained; then drop points from lines A and B in side elevation, crossing the lines of the same number in pattern; draw curved lines through points, completing pattern.

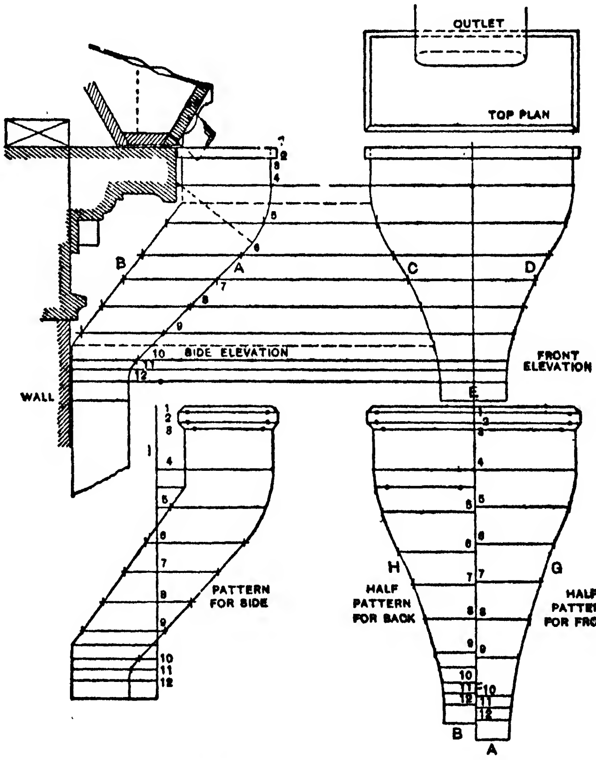


Fig. 103. Offsetting Conductor Head Pattern

PATTERNS FOR LEADER HEAD

To lay out a leader head to given dimensions, as shown in the sketch, Fig. 104, in which A is the leader head, 9×11 inches at the top and $4\frac{1}{2} \times 4\frac{1}{2}$ inches at the bottom. B indicates the flange, extending upward on the back. C indicates the opening cut into the bottom, to which the tube D is connected, and E shows the leader partly broken, showing how the tube D enters into the same in practice.

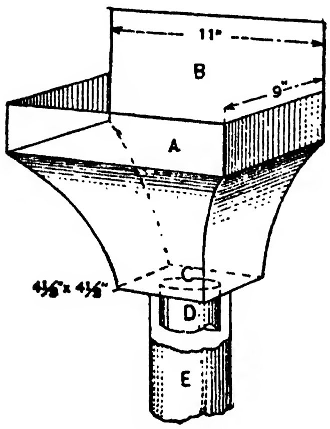


Fig. 104. Finished Article

There are two methods by which this head can be laid out. The first, or more complicated, method is to first draw a plan view of the given dimensions; then establish a given profile on either the front or side views, and follow the principles given.

The second, and simpler, method, such as is generally used in shop practice, is shown in Fig. 105, which is drawn to a scale of 2 inches to the foot.

First draw the side view of the head, as shown by A B C D, making A B equal to the desired width, or 9 inches, B C to the required hight, and C D to the desired width of $4\frac{1}{2}$ inches. Then draw the profile A 2 D. In line with the side view draw the one-half front view, as shown by E F G H, making G H equal to one-half the width of the front view, or $5\frac{1}{2}$ inches, and F E equal to one-half the desired width of $4\frac{1}{2}$ inches, or $2\frac{1}{4}$ inches. Then draw the profile H 2′ E. It will be noticed that owing to the difference in the projections the two profiles in front and side views are unequal.

To obtain the pattern for the front view proceed as follows: Divide the profile A D in the side view, as shown by the small figures 1 to 6. From these points, at right angles to B C, draw lines intersecting the profile H E in the front view from 1′ to 6′, as shown. Now extend the center line G F as shown by F M, upon which place the stretchout of the profile A D in side view, as shown by the small figures 1 to 6 on F M. At right angles to F M and from the small figures draw lines, which intersect with lines drawn parallel to the center line from similar numbered intersections in H E. Through the points thus obtained trace a line, as shown by 1 6 O N, which represents the half pattern for the front of the head to be formed after the profile A D in side view.

For the pattern for the side extend the line B C as shown by C P, upon which place the stretchout of the profile H E in the front view, being careful to transfer each space separately upon the line C P, as shown by points 1′ to 6′. At right angles to C P and through the small figures draw lines, which intersect with lines drawn from similar numbered points in the profile A D parallel to B C. Trace a line through intersections thus obtained, as shown by R S. Then will R S 6′ 1′ be the pattern for the sides, formed after the profile H E in front view. J, in the side view, indicates the rear flange, shown by B in Fig. 104, and by G K L H in front view in Fig. 105. The pattern for the back is pricked direct from the front elevation, one-half of which is shown by K L H E F G K. Trace the other half opposite the line K F.

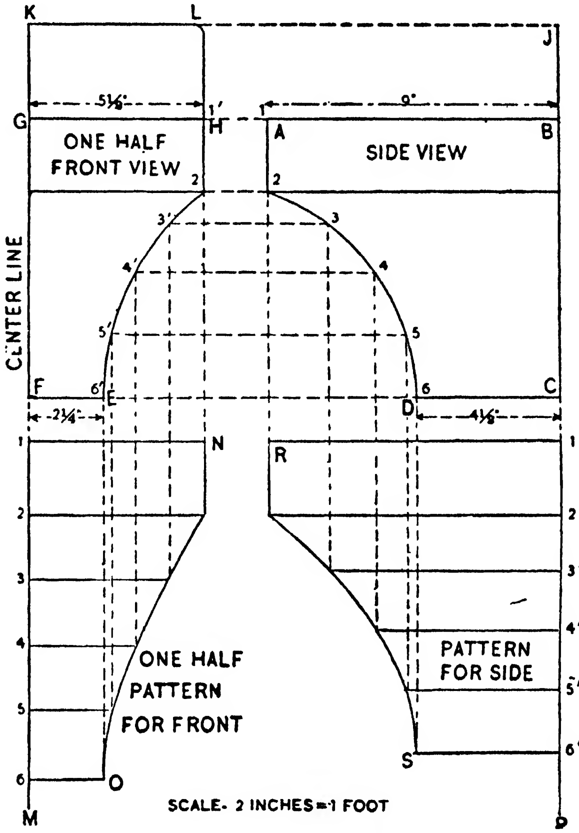


Fig. 105. Front and Side Views and Patterns

CONSTRUCTING CONDUCTOR HEADS

During the winter months, if times are slack, conductor or leader heads can be constructed with various size tubes fitting into round, square or rectangular pipes, for use when new leaders, heads and tubes are erected. There is no limit to the various designs which can be employed, using enrichments which are purchased from dealers in stamped zinc ornaments. When the head is placed in a court or yard not facing the outside the head is usually made plain, similar to that shown in Fig. 106, where the upper edge is beaded and reinforced by the corners A A. Care should be taken when soldering these heads that the joints and seams are

thoroughly soaked with solder, thereby obtaining a strong joint, for in the winter months, when the head is sometimes frozen, the expansion will cause the seams to burst if not strongly made.

Another form of head is shown in Fig. 107, where an enrichment, A, is soldered in position, as shown. Fig. 108 shows another style of head where an ornament

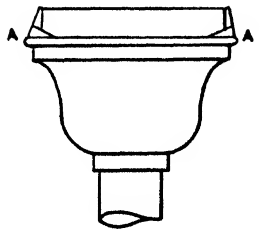


Fig. 106

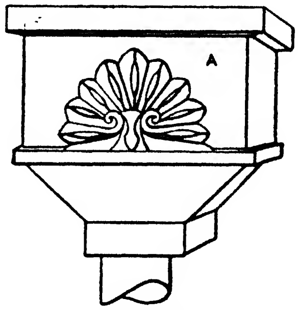


Fig. 107

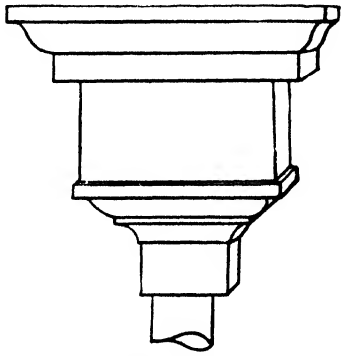


Fig. 108

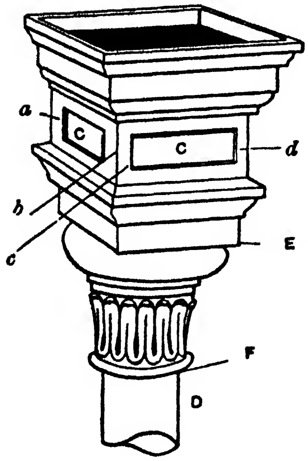


Fig. 111

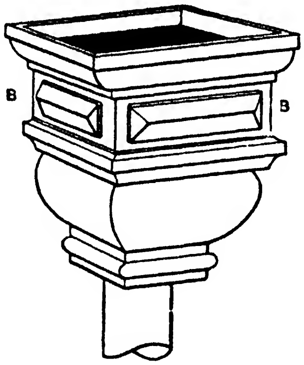


Fig. 109

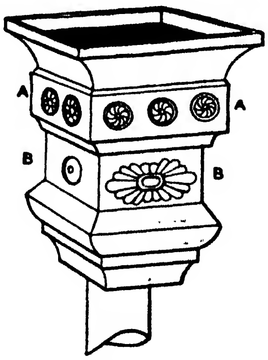
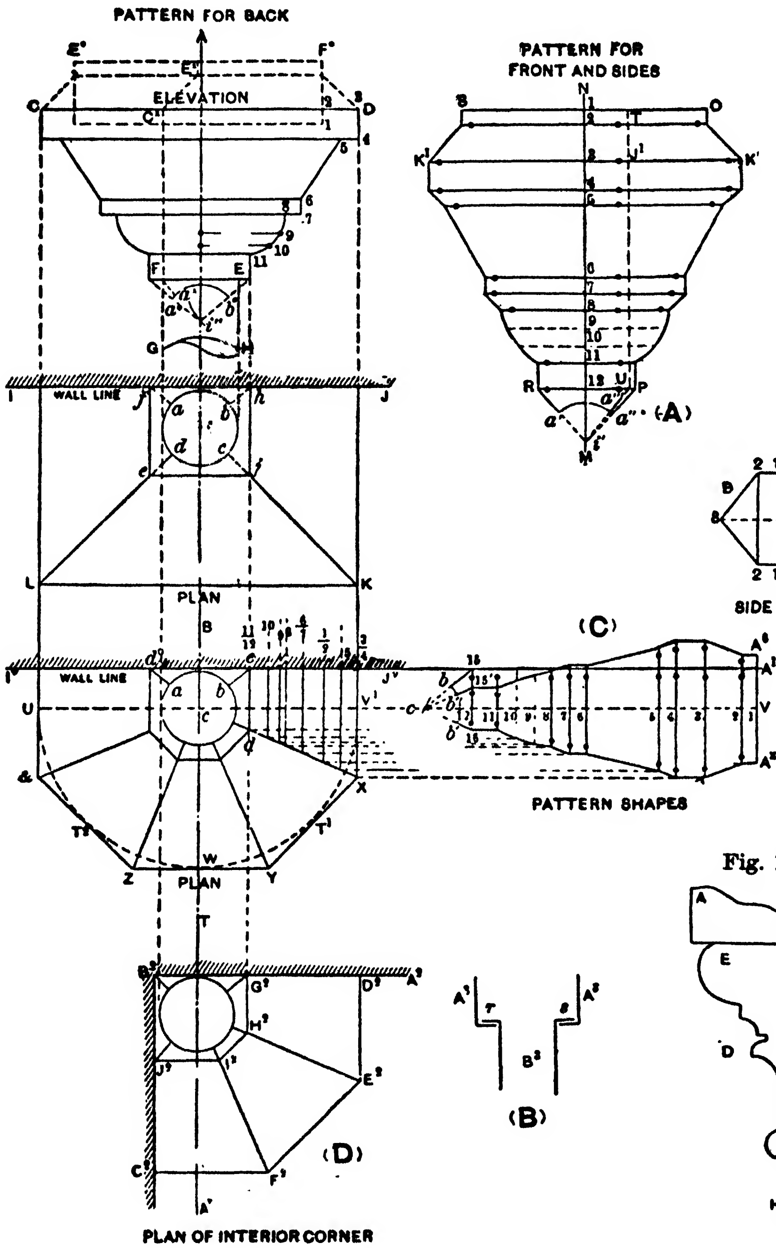


Fig. 110

REPRESENTATIVE STYLES OF CONDUCTOR HEADS

can be placed in the flat surface. Fig. 109 shows another molded head enriched with diamond shaped panels B B. Fig. 110 is enriched with rosettes and ornaments A and B. Fig. 111 shows an ornamental head with sunk panels C C, with mitered corners *a*, *b*, *c* and *d*. From E to F is shown a pressed capital, joining the head at E and the tube D at F.

The method of developing the small panel B in Fig. 109 and the corner pieces



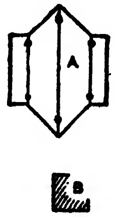


Fig. 114
Pattern for Corners
in Fig. 111

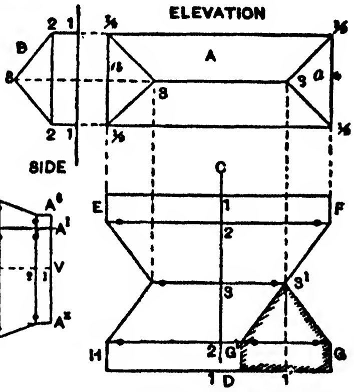


Fig. 113. Pattern for Diamond

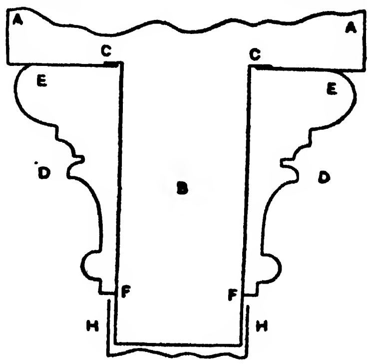


Fig. 112. Elevation, Plans and Patterns
of Various Shape Heads

Fig. 115. Joining the Capital

DEVELOPMENT OF PATTERNS FOR CONDUCTOR HEADS

of the panel C in Fig. 111 and joining the capital E F in a water tight manner will be explained. Heads are usually made square with round or other shaped tubes to join the leaders. Then, again, they are made octagonal or placed in an interior angle of a wall, in which case they are made octagonal in shape.

The rule to employ in developing these three styles of heads is explained in connection with Fig. 112, in which the principles there shown can be applied to the shapes shown in Figs. 106 to 111, inclusive, or any other shape head. The first pattern to be developed is that for a square leader head, Fig. 112, whose elevation is shown by C D E F and tube by F E H G. The three sides of the head are to be molded, as shown by J K L I in plan, the back I J to lay against the wall I J.

Through the center of the head draw the line A B. Now with radius equal to one-half of G H and with *i* on the center line A B as a center describe the plan of the tube so that it will barely touch the wall line I J, as shown. Draw the plan of the outer edge of the head, as shown by J K L I, making the distance from the center point *i* to the line L K equal to the distance of *i* to the line J K. From the corners K and L draw the miter lines toward the center point, meeting the circle at *j* and *e* respectively.

From E in elevation drop a line to the miter line, as shown by *h j*, and complete the rectangle *h j e f*. From *h* and *f* draw the lines to the center *i*, cutting the circle at *a* and *b*. The reason for drawing this small plan *f e j h* will become evident when developing the patterns. Allow an edge to turn on the inside of the top of the head, as shown in either Figs. 109, 110 and 111, and as shown by 3 2 1 in Fig. 112.

Divide the profile D E into equal parts, as shown from 1 to 12. Take the stretchout of D E and place it on the vertical line M N, as shown by similar figures, through which draw horizontal lines. Now, measuring from the center line A B in elevation, take the various projections to points 1 to 12 and place them on similar numbered lines measured on both sides of the line M N and resulting in the miter cut O K^v P R K^1 S, when a line is traced through points thus obtained.

With radius equal to *i e* or *i j* in plan and with either R or P in (A) as center draw an arc, cutting the center line N M, as shown at i'. Then with radius equal to *i c* in plan and i' in (A) as center draw the arc a' a''. From R and P draw lines to the center i', intersecting the arc a' a'' at a' and a''. Then will a' R S O P a'' be the pattern for the front of the head.

To obtain the pattern for the side take the distance from K to J in plan and place it, as shown, from K^1 to J^1 in (A), and through J^1 parallel to N M draw the vertical line, meeting the top and bottom of the pattern at T and U. From U draw

a line to the center i', cutting the arc at a'''. Then S T U a''' a' R S will be the pattern for the sides.

Take a tracing of the miter cut K_v O and place it as shown by D. F° and C E° in elevation. Also take a tracing of a b h f in plan and place it in elevation, as shown by F E $b°$ $a°$, the arc $b°$ $a°$ being struck from the center i'', obtained as explained in connection with (A). Then E° C F $a°$ $b°$ E D F° E° will be the pattern for the back. Edges for soldering should be allowed along the back and front and the tube soldered in position, as shown by (B), in which A^3 A^3 shows the head and B^3 the tube flanged and soldered to the bottom of the head at r and s.

Assuming that an octagon head is desired whose plan is shown by V^1 X Y Z & U and whose elevation is similar to D E F C, then the first step is to draw the plan view as follows: Draw the wall line 1^v J^v, through which extend the center line as B T. On B T, using c as center, describe the plan of the tube, as shown, nearly meeting the wall line, as in the square plan. Through c parallel to the wall line draw U V. With c as center and c U as radius describe the semicircle U W V^1. Around this semicircle construct the semioctagon by drawing a vertical tangent line at V^1, a tangent line at 45° at T^1 and a tangent horizontal line at W, forming intersections at X, Y, Z and &. From X, Y, Z and & draw miter lines to the center c. From E in elevation draw the vertical line, meeting the miter line drawn from X at d. Then complete the plan e d $d°$ and from e and $d°$ draw lines to the center c, meeting the circle at a and b. In practice but one-half of this plan is required.

Now from the various points 1 to 12 in elevation drop lines intersecting the miter line X d in plan, as shown. Take the stretchout of D E and place it on U V, as shown, and through the points draw vertical lines, which intersect with lines drawn from similar numbers on the miter line X d. Measuring from the center line 12 1 in (C), take the various distances to points in the miter cut just obtained and transfer them to the opposite side, as shown from A^6 to 16′. Trace a line through points thus obtained, then will A^x A^6 16′ 16 be the pattern for the sides marked T^1, W and T^2 in plan. With 16 in the pattern as center and d c in plan as radius describe the arc c'. With c' as center and c b in plan as radius describe the arc b b'. From 16 and 16′ in the pattern draw lines to the center c', cutting the arc at b' and b''. Then b'' A^6 A^x b' is the complete pattern.

Extend the wall line I_v J_v to A^1 in the pattern and draw a line from 15 to c', cutting the arc at b. Then b 15 A^1 A_x 16 b' is the pattern for the two sides shown in plan by V^1 and U. The pattern for the back is similar to the pattern for the back of the square head, excepting that a b e $d°$ in plan must be traced to the line F E in elevation.

If a leader head were required for an interior corner, shown by $A^2 B^2 C^2$, the patterns just described could be used. Thus the pattern $A^1\ b\ b'\ A_x$ in (C) could be used for the sides $D^2 G^2 H^2 E^2$ and $F^2 I^2 J^2 C^2$ in (D), while the pattern $A^6\ b''\ b'\ A_x$ in (C) could be used for the side $E^2 H^2 I^2 F^2$ in (D). The pattern for the back $D^2 B^2$ and $B^2 C^2$ is obtained as follows: Extend the line $C^2 B^2$ until it intersects the line C D in elevation at C_x; then take a tracing of the miter cut C E° and place it, as shown, from C_x to E_x, and draw a line from F to the center i'', intersecting the arc $a^\circ\ b^\circ$ at a_x. Then $E_x\ F^\circ$ D E $b^\circ\ a_x$ F $C_x\ E_x$ will be the pattern for the flat back, of which two will be required, one for $D^2 B^2$ and the other for $B^2 C^2$ in (D).

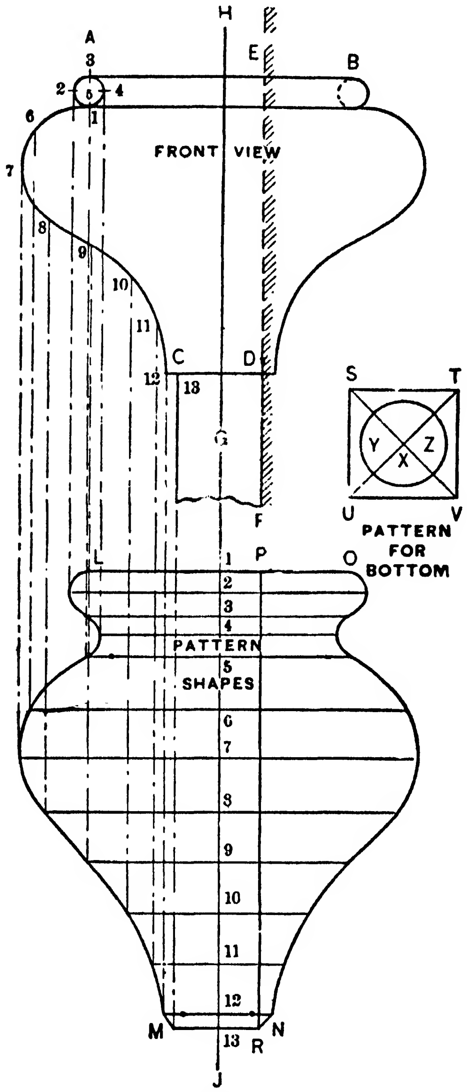
Fig. 113 shows how the diamond shaped panel B in Fig. 109 is developed. Let A be the elevation of the panel and B its side or section. At right angles to the lines in A draw the stretchout line C D, upon which place the stretchout of the side B. E F G H will be the pattern for A. For the patterns for the heads *a* and *a* drop a vertical line from 3′ in the pattern, as 3′ 1′, and transfer the outline of 3′ G to the symmetrical position 3′ G^1, obtaining the shaded part.

When the head shown in Fig. 111 is put together the panel C should be mitered and soldered at the corners and then the panel ends *a*, *b*, *c* and *d* soldered in position. This makes a tight job. The pattern for these panel ends would look like A in Fig. 114, bending them as shown at B.

The method of constructing the head to the tube and capital E F in Fig. 111 is shown in Fig. 115, where A A shows the head and B the tube, flanged and soldered at C and C; the capital D D is then slipped over the tube B and soldered at E and E and at F and F from the outside. The tube is allowed to project below F F and enters the leader at H H.

PATTERN FOR PLAIN LEADER HEAD

The front view of a molded leader head, which can be made in the tin shop without the use of a cornice brake, is shown in Fig. 116, the small flange at the bottom of pattern M N being bent on the hatchet stake or by means of flat plyers. For the patterns proceed as follows: Let A B C D represent the front view of the



Pattern for Plain Leader Head—Fig. 116—Elevation and Pattern

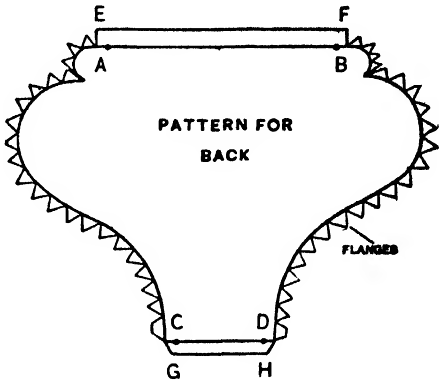


Fig. 117. Pattern for Back

head and G the leader tube. In line with one side of the leader tube draw the line F E; then will A E D C represent the side view of the head. Through the center of the head draw the line H J. Now divide the profile of the head A C into equal spaces, as shown by the small figures 1, 2, etc. On the center line, commencing at 1, lay off a stretchout of the profile A C, as shown by the small figures. At right angles to it and through the small figures draw lines, which intersect with those of similar numbers drawn parallel to the center line H J from divisions on the profile A C. Trace a line through points thus obtained, as shown by L M. Trace the miter cut opposite the center line, as shown from O to N. Then will L M N O be the pattern for front of head. Extend the line E F in front view, as shown by P R in pattern; then will L M R P be the pattern for the sides. For the pattern for the bottom in head, draw a square figure, shown by S T U V, each side being equal to C D or M N. Draw diagonal lines T U, S V until they intersect at X. Now with X as center and the required radius draw the circle Y Z, which equals the diameter of the leader tube G.

In Fig. 117 A B C D is a reproduction of A B C D in Fig. 116. A flange, E F in Fig. 117, is added, which is bent inward, as shown at E of Fig. 116. Allowance is made for flanges on the pattern for the back in Fig. 117, as shown by E G and F H.

MAKING CONDUCTOR HEADS, SQUARE IN PLAN

The variety of designs which may be produced of leader or conductor pipe heads is so large as to be practically without limit. Some of these designs are presented in the illustrations following, as are also the methods of laying out the patterns. In Figs. 118, 119 and 120 are represented the methods of obtaining the patterns for a plain leader head, the first illustration representing the plan, elevation and pattern for the front, the second showing the plan, elevation and patterns for the sides, and the third figure the plan, elevation and pattern for the rear of the head. The three plans and elevations are not necessary in obtaining the patterns, but are given in order to make clear every step taken. All that would be necessary in obtaining the patterns would be the plan and elevation shown in Fig. 118, and knowing how far the head projects over the wall line, as indicated in plan from D to C, or A to B, the front pattern would be used to mark the cut for the sides, and for the flat head in the back, indicated in the plan from A to D, the front elevation shown by K L M N would simply be pricked through onto the metal. Now, to make each step clear, let A B C D, Fig. 118, represent the plan of the head, corresponding to K L M N of the elevation, and E the plan of the leader, corresponding to O of the elevation. As the profile of the head, shown by N M of the elevation, contains no curve and all lines are straight, only the corners of bends are numbered, as indicated by 1, 2, 3, 4, etc.

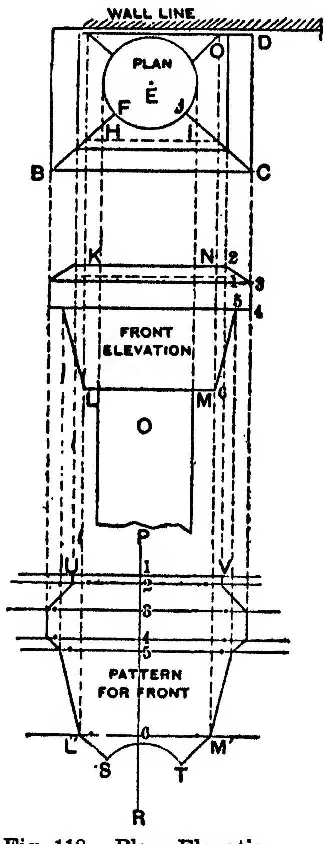


Fig. 118. Plan, Elevation and Pattern for Leader Head with Round Pipe

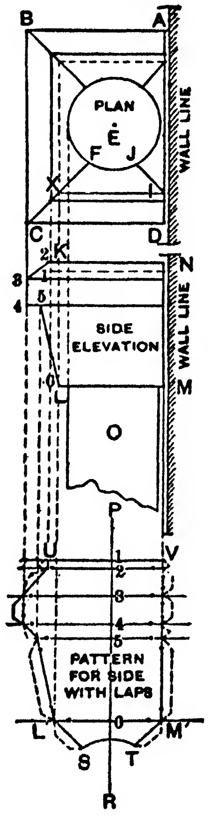


Fig. 119. Plan, Elevation and Pattern for Sides of Leader Head with Round Pipe

For the pattern of the front, corresponding to the front elevation, pro-

ceed as follows: At right angles to L M of the elevation draw the stretchout line P R, upon which place the stretchout of the profile N M of the elevation, as shown by 1, 2, 3, 4, etc., on the stretchout line P R. At right angles to P R, and through the small figures, draw lines indefinitely, as shown, which intersect with lines of corresponding numbers drawn from the small figures in the elevation at right angles to L M. A line traced through these intersections, as shown by U V L′ M′, will be the pattern for the front.

To obtain the pattern for the lower bend 6 M, as shown in elevation, Fig. 118, proceed as follows: Where the bottom of the head intersects the leader head, as at M 6, draw upward from the bend 6 a dotted line, represented in the plan by I O and cutting the miter line J C at I. From the intersection I and at right angles to D C draw a dotted line cutting the miter line F B at H. Now take a duplicate of H I J F and transfer it to the pattern, as shown by L′ M′ T S, which completes the pattern. The small dots shown on the pattern indicate the bends.

For the pattern of the sides of the head, proceed as follows: Let A B C D of Fig. 119 represent the plan of the head, corresponding to the side elevation shown by K L M N, and let E represent the plan of the pipe or leader, corresponding to O of the side elevation. It will be noticed the plan and elevation of the side corresponds to that of the front, with the exception that it is viewed from the side in Fig. 119. At right angles to L M of the side elevation, Fig. 119, draw the stretchout line P R, upon which place the stretchout of the profile K L of the side elevation (which also corresponds to M N of the front elevation Fig. 118), as shown by the small figures on the stretchout line P R. At right angles to P R and through the small figures draw lines indefinitely, as shown, which intersect with lines of corresponding numbers drawn from the small figures in the profile of the side elevation at right angles to L M. A line traced through these intersections, shown by L′ M′ V U, will be the required pattern.

For the pattern of the bottom bend, 6 L, proceed as follows: From the point or bend 6, in the side elevation, draw a dotted line upward at right angles to L M, cutting the miter line C F in plan at X. From the intersection X and at right angles to C B draw the dotted line X I, intersecting the wall line, as shown. Now take a duplicate of F X I J in plan, and place it in the pattern as shown by L′ M′ T S, which completes the pattern for the sides. Laps have been allowed on pattern as shown by the dotted lines, and the small dots indicate the bends.

In Fig. 120 is shown the plan, elevation and pattern for rear of head, which corresponds to the plan and elevation shown in Fig. 118, except that the plan and elevation in Fig. 120 are viewed from the rear. A B C D of Fig. 120 represent

the plan of the head, corresponding to K L M N of the elevation, and E in the plan shows the pipe or leader, corresponding to O of the elevation. For the pattern for the rear of head, simply prick through the rear elevation direct upon the metal, by means of a scribe awl or prick punch and hammer, and the result will appear as shown in pattern by U V M′ L′. Now, from the corner L in the rear elevation draw a dotted line upward at right angles to L M, cutting the miter line H F and the rear line D A in plan at H. Draw a line from H parallel to D A cutting the miter line I J at I. Take a duplicate of H I J F in plan, and transfer it as shown in pattern by L′ M′ T S, which completes the pattern. The dots on the line L′ M′ in pattern indicate the bends. This completes the entire set of patterns required for the leader head shown in front, side and rear elevation in Fig. 118, 119 and 120; and these patterns could be used whether the leader was square, round or octagon. The only change required on the pattern, providing the leaders were square or octagon, would be that the curve shown in the three patterns by S T would be a straight line for that given size of square leader, or a portion of an octagon in shape for the given size of an octagon leader.

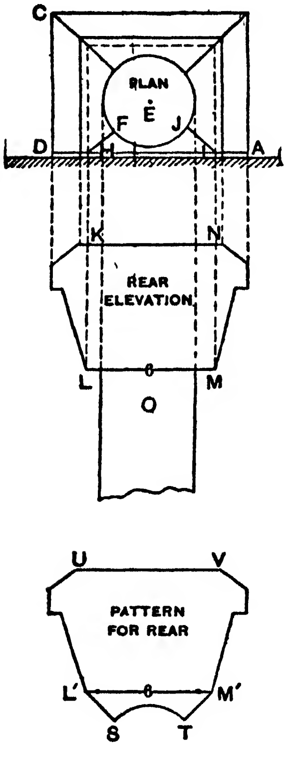


Fig. 120. Plan, Elevation and Pattern for Rear of Leader and Head

It is usual to make different sizes of heads to correspond to the different diameters of leaders used. The following will give a good proportion of the sizes of the leader heads used in connection with the leaders of different diameters:

Diameter of leaders, in inches....	Size of top opening of head, in inches: Side	Front
....3	4½	x 5½
....4	6	x 7
....5	6½	x 8
....6	8	x 9

The patterns having been cut for the head, the next step is to prepare the tube, which is to be soldered into the head. Tube is usually made about 6 inches in length, and the diameter a little smaller than the size of leader used, so that the tube will easily slip into it. After rolling the tube, and riveting and soldering it, a flange not less than ⅜ inch should be stretched upon it, which in turn is soldered to the leader head. In stretching any flange it is usual to run the pipe through the turning machine, thus giving the article a small groove, which guides the workman in stretching, and does away with the sharp corner, which is not necessary in work of

this kind. In Fig. 121 is shown the appearance of a round tube after passing through the turning machine.

It will be noticed that the groove A is dented inward, and in stretching is laid against the corner of the square stake shown at C of Fig 122, thereby enabling the workman to have an even flange, as before explained.

Fig. 122 shows the proper method of flanging a round tube. F G H J represent a wooden bench or bench plate; L, M and N, the square stakes; C, D and E, the tubes; V and W, the stretching hammers; and X, the wooden mallet. After the tube C of Fig. 122 is run through the turning machine, Fig. 121, the groove in the tube is placed upon the square stake, as shown in Fig. 122, in the first operation, and with the use of the stretching hammer V, and gradually turning and striking the tube alternately, the flange is drawn out or stretched as much as is indi-

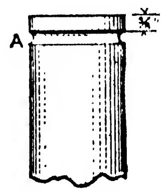


Fig. 121. Appearance of a Round Pipe After Passing through the Turning Machine

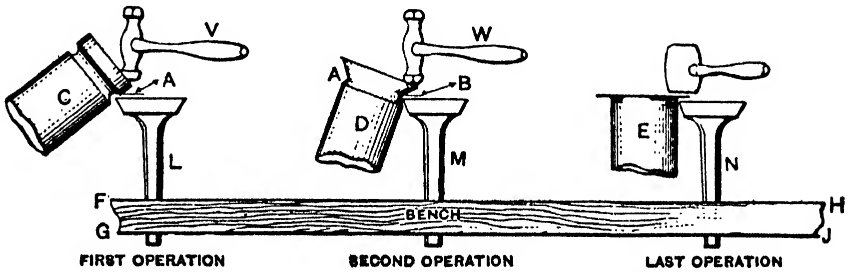


Fig. 122. Method of Flanging the Round Pipe or Tube

cated by the arrow line A; bearing in mind that the force of the blow should be the same at every stroke, or else the profile of the opening of the tube will not be a true circle. Now take the tube C and place it as shown at D in the second operation, striking and gradually turning the tube alternately, using the same stretching hammer as shown at W, until the flange is drawn out or stretched as indicated by the arrow line B. Finally, take the tube D and place it as shown at E in the last operation, and with the use of the wooden mallet X level the flange until it has the appearance shown. Fig. 123 gives a perspective view of the same tube flanged out by the foregoing method, which is the proper way of doing work of this kind, the stretched flange being shown at A.

In Fig. 124 is indicated the improper method of flanging the tube by means of notching with the shears and bending, the improper flange being shown at A.

The turning machine, square stake, bench plate and stretching hammer, above referred to, can be purchased from wholesale dealers in tinners' supplies. The bench plate is not necessary if the holes are properly cut into a solid bench,

although the plate comes very handy, because it contains the different size openings required for different tools.

In Fig. 125 is shown the method of forming upon the hatchet stake with the use of a mallet the leader head represented in Fig. 118. Let C D F E represent the bench, U, V, W, Y, Z the hatchet stakes and X the wooden mallet. Let A J in the first operation represent one of the sides of the leader head shown in Fig. 118, the small figures on the line A J being similar to those on the two patterns shown in Figs. 118 and 119. A small strip of metal should be first formed so as to see which way the molding forms best. In this case we will commence at the lower bend 6. Now notice the first operation in Fig. 125. A J represents one of the sides of the leader head and is laid against the hatchet stake U in the position as shown, on the bend 6, and A 6 is bent over until it has the angle shown in the front elevation in Fig. 118 by 4 6 M, which is indicated in the first operation in Fig. 125 by 6 B. Now reverse the side and place the bend 5 upon the hatchet stake in the second operation in the position shown. Press down upon A and make the angle 4 5 B correspond to the angle 4 5 6 in the front elevation, Fig. 118, always bearing in mind to use the mallet X to obtain a sharp corner. Now reverse the side again, and place the bend 4 upon the hatchet stake in the third operation, placing it in the position shown and holding the bend 4 firmly against the hatchet stake. Use the mallet X and make a small crease along the bend 4 by firmly striking the mallet along the bend. Press down upon A, making the angle 5 4 B correspond to the angle 5 4 3 in the front elevation, Fig. 118. Now reverse the side again, placing the bend 2 upon the hatchet stake as shown in the fourth operation and using the mallet as before explained. Make the angle 3 2 1′ correspond to the angle 3 2 1 in the front elevation, Fig. 118. Now place the side of the head upon the bend 3 (not reversing it) on the hatchet stake in the fifth operation and make the angle 4 3 2′ correspond to the angle 4 3 2 in the front elevation, Fig. 118, which completes the profile as shown by 1, 2′, 3, 4, 5 and 6 in the fifth operation. The pattern for the rear has only one square bend upon the line 6, as shown in Fig. 120. After the entire head is formed it is soldered together water tight, and finally the tube shown in Fig. 123, is also soldered in place. When finished it has the appearance shown in Fig. 126, in which A shows the laps indicated on the pattern for sides in Fig. 119.

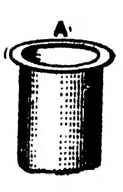


Fig. 123. Appearance of Properly Flanged Tube or Pipe

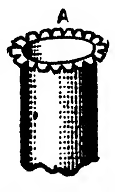


Fig. 124. Improperly Flanged Tube

In Fig. 127 is represented a front elevation showing for what purpose the

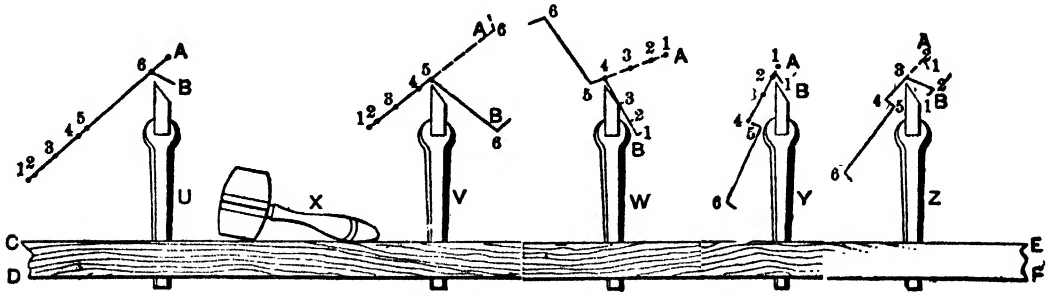


Fig. 125. The Five Operations Necessary in Bending on the Hatchet Stake, with the Mallet, the Leader Head Indicated in Fig. 118

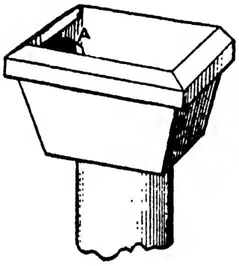


Fig. 126. View of Leader Head Indicated in Fig. 118

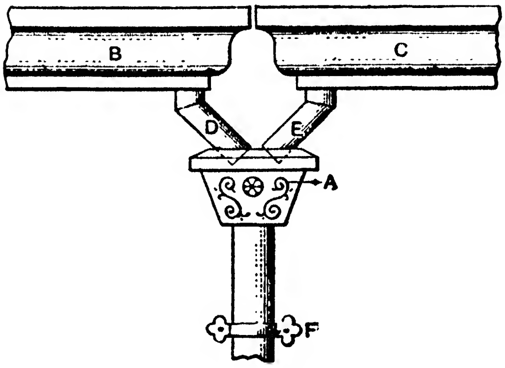


Fig. 127. Showing Manner of Using the Leader Head

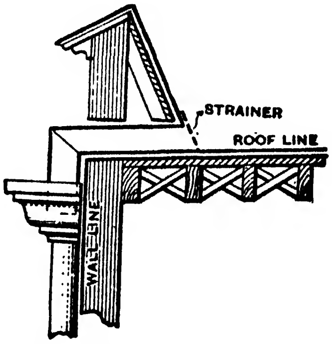


Fig. 128. Section Showing a Valley Connected to an Elbow Passing through the Wall of a Building into a Leader Head

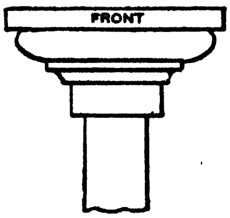


Fig. 129.
A Plain Molded Head

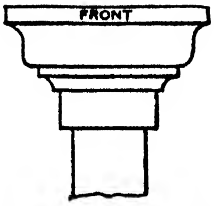


Fig. 130.
Another Style of Head

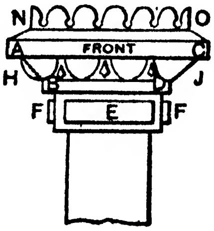


Fig. 131.
A More Ornamental Leader Head

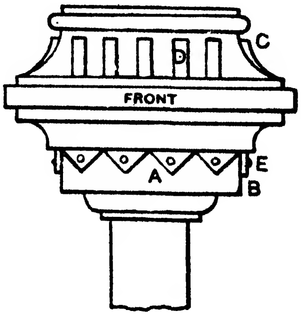


Fig. 132.
A Still More Elaborate Design of Head

leader head is employed. B and C represent two molded gutters, connected to the two elbows D and E, which in turn pass into the leader head as shown. If desired, small scrolls could be cut from sheet metal, raised from 1/4 to 1/2 inch, and tacked with solder upon the face of the head, as indicated at A in Fig. 127. F represents a sheet metal band placed over the leader hook. Fig. 128 is a sectional view showing a valley connected to an elbow, passing through the wall of a building into a leader head, which is another illustration of the purpose for which the head can be employed.

There is no limit to the number of the designs which can be produced if the tinner will exercise a little patience. In Figs. 129 and 130 are shown plain molded leader heads, the patterns of which are obtained in the same manner as shown in Figs. 118, 119 and 120.

In Fig. 131 is shown a more ornamental leader head, having raised panels on front and sides indicated by F E F, egg and dart molding, as shown by H J, and a small scallop cut out at the top, as shown by N O. The scallop would be cut out and simply tacked upon the top of the head. The egg and dart molding can be purchased from dealers in pressed zinc ornaments. If egg and dart molding was required, the head would be bent as shown from C to D and B to A, upon which the egg molding J and H would be tacked with solder. The panel E would be pricked directly off the elevation, and the depth of the strip shown at F and F added to it. In Fig. 132 is shown another form of leader head more elaborate in construction. Stripping it of all enrichment D and A, we have only moldings placed in proper proportions to give a pleasing effect to the eye, thereby showing that if the tinner will give a little time to drawing different moldings, so that each member is in proportion to the other, it will be worth the time invested in case other cornice work comes to hand. The enrichments shown at A and D in the front view in Fig. 132 are simply pricked from the face of the drawing by placing a piece of sheet metal under the drawing and pricking through the triangular dentil A, and adding to it the hight of the strip B. The small ball shown at E would be obtained from pressed zinc ornament manufacturer, and tacked with solder on the dentil as shown. The dentils would be tacked against the sides and front of the head in the position as shown. For the projections on the top of the head, prick off the section C and solder on the face edge a strip as wide as indicated at D. The pattern would be obtained in the same manner as shown in Figs. 118, 119 and 120.

MAKING SQUARE MOLDED CONDUCTOR HEADS

In Figs. 133, 134 and 135 are shown the plans, elevations and patterns required for a square molded leader head, the leader to be square in plan and to stand away from the wall as indicated by A in the plan views. Let B C D E in Fig. 133 represent the plan of the leader head, corresponding to J K L M of the elevation, and F G H I the plan of the square pipe, corresponding to O of the elevation. The dotted lines drawn from the elevation to the plan show their relationship to each other. The dotted line 13 X, drawn across the leader O of the elevation, indicates the flange which will be added to the pattern, the length of which is shown from 12 to 13 in elevation. For the pattern of the front proceed as follows: Divide the curved portions of the profile J L of the front elevation, Fig. 133, into an equal number of parts, as shown by the small figures. At right angles to L M of the front elevation draw the line S T, upon which place the stretchout of the profile J L, as shown by the small figures on the line S T. At right angles to S T and through the small figures draw lines indefinitely as shown, which intersect with lines of corresponding numbers dropped from the profiles J L and K M at right angles to J K. Lines traced through these intersections, as shown by N P and O R, will be the desired pattern for the front of head.

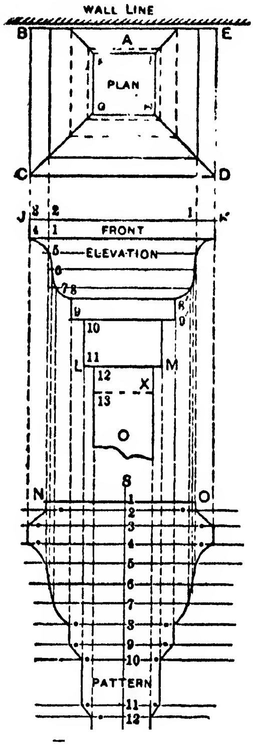


Fig. 133. Plan, Elevation and Pattern for Front of Leader Head

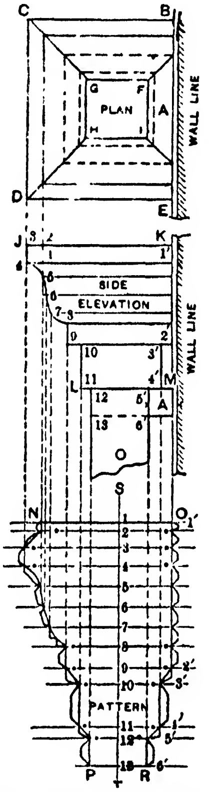


Fig. 134. Plan, Elevation and Pattern with Lap for Side of Leader Head

In Fig. 134 is shown the plan, elevation and pattern for the side of the leader head. C B D E represents the plan of the head, corresponding to J K L M of the elevation, and G F H I shows the plan of the square leader, corresponding to O of the elevation. As before explained the leader stands away from the wall, as is indicated by A in plan and side elevation, Fig. 134. It will be noticed that the profiles are alike in the three elevations shown in Figs. 133, 134 and 135, and that part of the same profile is shown on the side elevation, as indicated by 2′, 3′, 4′ and 5′ in Fig. 134, which fills out the projection

from the wall. For the pattern of the side proceed as follows: Divide the curved portions of the profile J L into an equal number of parts, as shown by the small figures. At right angles to J K of the side elevation draw the line S T, upon which place the stretchout of the profiles J L in the side elevation, as shown by the small figures on the line S F. At right angles to S T and through the small figures draw lines indefinitely, as shown, which intersect with lines of corresponding numbers drawn at right angles to J K of the side elevation, from the small figures in the profiles J L and M K. Lines traced through these points of intersection, as shown by N P and O R, will be the required pattern for the sides of the leader head, of which two would be needed, one formed right and the other formed left. The lines numbered 1′, 2′, 3′, 4′, 5′ and 6′ shown outside of the pattern in Fig. 134 correspond to the same numbers shown in the profile of the side elevation facing the wall line. Laps are allowed on the pattern of the side pieces, thus avoiding them on the front and rear pieces. In Fig. 135 is shown the plan, elevation and pattern for the rear of the leader head. D E B C indicates the plan, corresponding to J L M K of the elevation, and H I F G shows the plan view of leader, corresponding to O of the elevation.

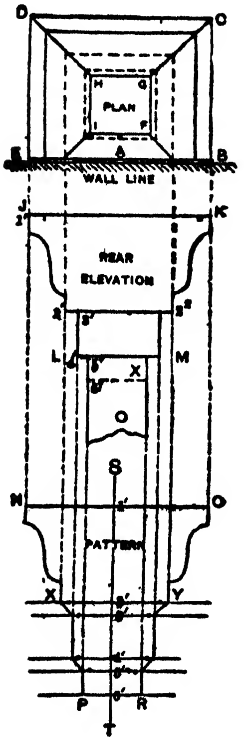


Fig. 135. Plan, Elevation and Pattern for Rear of Leader Head

With the usual projection A, it will be noticed that J 2′ 2^3 K, of the rear elevation in Fig. 135 is simply a flat piece of the same shape as shown in front elevation in Fig. 133 by J 9 9′ K, the side view of which is shown by 1′ 2′ in the side elevation of Fig. 134. The dotted lines drawn from the side elevation to the rear elevation show the relationship of parts indicated by similar numbers. Number the bends shown in the rear elevation, 1′, 2′, 3′, 4′, 5′ and 6′, corresponding to the figures shown from K to M of the side elevation, Fig. 134. For the pattern of the rear of head proceed as follows: At right angles to J K of the rear elevation, Fig. 135, draw the line S T, upon which place the stretchout of the profile K M of the side elevation, Fig. 134, as shown by the small figures on the line S T in Fig. 135. At right angles to S T and through the small figures draw lines indefinitely, as shown, which intersect with lines of corresponding numbers drawn from the numbered heads at right angles to J K of the rear elevation. A line traced through these intersections, as shown by X P R Y, will be part of the rear pattern. For the remainder proceed as follows: The remaining portion above is a duplicate of J 2′ 2^3 K of the

rear elevation. In Fig. 136 is shown the finished view of the leader head, as seen from the rear. The bends marked 1′, 2′ 3′ and 4′ 5′, Fig. 136, indicate bends of similar numbers shown in the rear elevation.

At A of Fig. 136 are shown some of the laps indicated on the pattern of the side shown in Fig. 134. Fig. 137 represents an end view of the former and indicates the method of forming the ogee moldings.

Select the proper size pipe or former and place it in its cross groove. Let J L

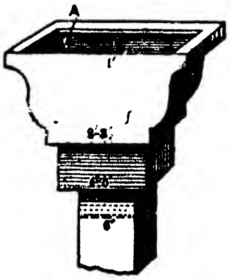


Fig. 136. General View of Leader Head Indicated in Fig. 133

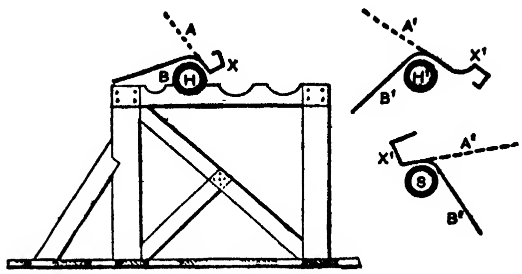


Fig. 137. Method of Forming the Ogee and Cove on the Former

in Fig. 133 represent the molded head to be formed. The bends 2, 3 and 4 in the profile J L are bent upon the hatchet stake as explained previously, and then placed upon the former H in Fig. 137 in the position shown by X A. Hold X firmly against the former and press down A, and it will look as shown by X B. Now place X B upon the former H^1 in its proper position as shown by X^1 A^1. Hold X^1 firmly against the former and press down A^1 and it will look as shown by X^1 B^1, which completes the ogee. The square bends shown by 8, 9, 10, 11 and 12 in the profile J L, Fig. 133, are made upon the hatchet stake.

MAKING AN OCTAGON CONDUCTOR HEAD

In Fig. 138 are shown the elevation, plan and patterns of an octagonal leader head. A B C D represents the front elevation, corresponding to E G H I J F of the plan, C D O of the elevation corresponding to the plan of the octagon leader shown by L M N O P R S K. The dotted lines drawn from the plan to the elevation show their relation to each other. The two miter lines shown in elevation by X X are not necessary in the development of the pattern. After the plans of the leader and head have been properly drawn, as shown in Fig. 138, connect the

corners of the leader to the corners of the head by miter lines, as indicated by N J, I O, P H and G R. For the several patterns proceed as follows: Divide the curved portion of the profile B D of the front elevation into an equal number of parts, as indicated by the small figures.

From these, and at right angles to A B of the elevation, draw lines through the plan view cutting the miter line N J, as shown. From the intersections obtained on the miter line N J draw lines parallel to J I cutting the miter line I O; likewise from the intersections on the miter line I O draw lines parallel to I H intersecting the miter line H P. As the front of the head D′ in plan is the same as E′ and C′, it will only be necessary to obtain the pattern for the front D′, which can be used for E′ and C′.

As the side of the head A′ in plan is the same as the opposite side B′, it will only be necessary to obtain the pattern for A′, which can be used for B′, reversing it in forming. For the pattern for the side of the head shown by A′ in plan, draw a line at right angles to F J, as shown by T′ S′, upon which place the stretchout of the profile B D of the front elevation, as shown by the small figures on the line T′ S′.

At right angles to T′ S′, and through the small figures, draw the usual measuring lines indefinitely, as shown, which intersect with lines of corresponding numbers drawn at right angles to F J from the intersections on the miter line J N. Now trace a line through the intersections as shown from W′ to X′. At right angles to F J extend the line E F of the plan indefinitely on to the pattern, as shown by the line U′ Y′. Then will W′ X′ Y′ U′ be the pattern required for the sides A′ and B′ in plan.

For the pattern of the front proceed as follows: At right angles to H I of the plan draw the stretchout line T U, as shown, upon which place the stretchout of the profile B D of the elevation, as shown by the small figures. At right angles to T U, and through the small figures, draw lines indefinitely, as shown, which intersect with lines of corresponding numbers drawn at right angles to H I from the intersections on the miter lines H P and O I. Lines traced through these intersections, as shown by V X and W Y, will be the required pattern for the sides E′, D′ and C′ of the plan.

In practice it would only be necessary to obtain the pattern for the side A′ in plan, because the angles J I H G are alike, thus making the miter cuts on all of the patterns the same. The following will illustrate how the front pattern is obtained by using the side pattern. Let W′ X′ Y′ U′ represent the pattern for the side A′, and let V W in the pattern of the front represent a straight line drawn on a sheet of metal. Now take the pattern of the side, and place W′ U′ upon the line

V W on the metal and mark the miter cut V X. Now take the distance P O of the plan in the dividers, and place it as shown by X Y in the pattern. Now reverse the pattern of the side and place the edge U′ W′ upon the line V W on the sheet of metal, making the corner X′ in the pattern of the side meet the corner Y previously obtained with the dividers, and draw the miter cut W Y, which completes the pattern. For the pattern for the flat piece forming the back, shown by E F,

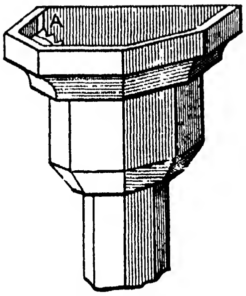
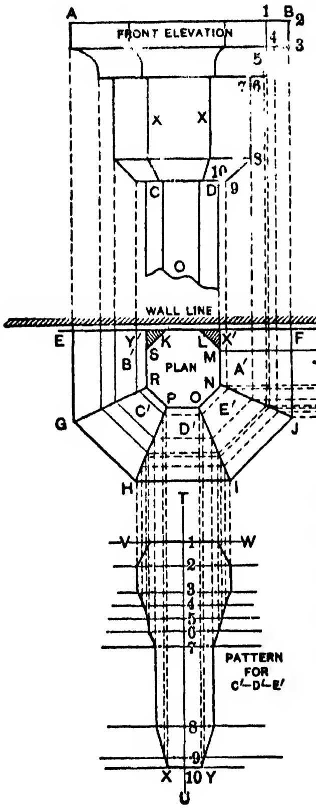


Fig. 139.
General View of Leader Head indicated in Fig. 138



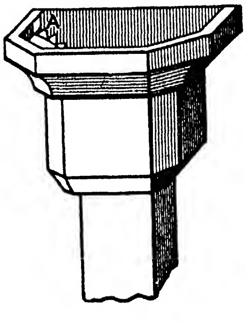


Fig. 141.
General View of Leader Head indicated in Fig. 140

Fig. 138.
Elevation, Plan and Patterns for an Octagonal Leader Head

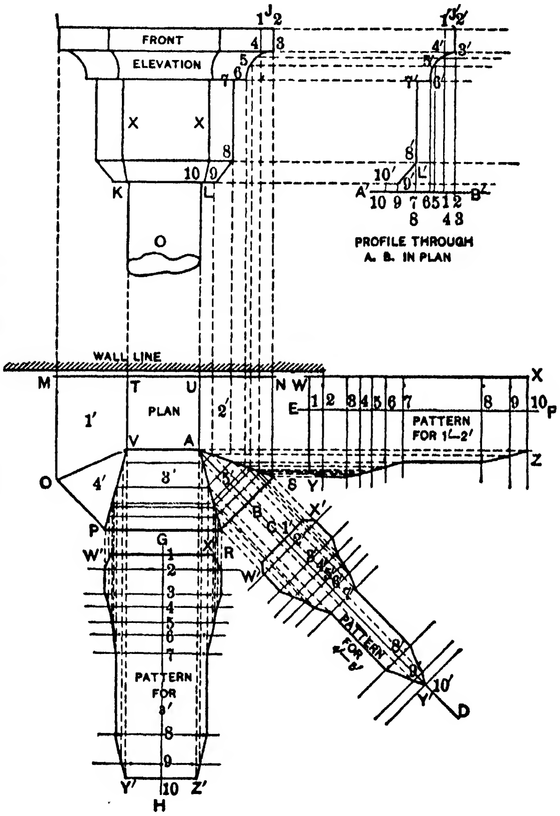


Fig. 140.
Elevation, Plan and Patterns for an Octagon Head Connecting with a Square Leader

Fig. 138, place a sheet of metal of the required size under the front elevation and prick through with a scribe awl as much as is indicated by A B D C. If the leader head was put together and the octagon pipe joined to it there would be found two openings, indicated in the plan by the shaded lines X′ L M and K S Y′. To avoid this duplicate the triangle Y′ S K and place it on the pattern for sides, as indicated by the shaded lines Y′ V′ O′, which completes the entire set of patterns required for an octagonal leader head joining to an octagon leader. Fig. 139 shows a per-

spective view of the finished leader head, as seen from the front and top.

A indicates the laps which are placed on the sides of the pattern and soldered water tight to the flat back.

In Fig. 140 are shown the elevation, plan and several patterns required to construct a leader head, forming a transition from a square leader to an octagon head. Let I J L K represent the front elevation, corresponding to M O P R S N of the plan, K L O of the elevation corresponding to the leader T U A V of the plan. The miter lines shown in the front elevation by X X are not necessary in the development of the patterns, but are only shown to give a front view of the article when finished. The dotted lines drawn from the elevation to the plan show their relationship to each other. After the plan of the leader and leader head have been properly drawn construct the miter lines in plan, as indicated by A S, A R, V P and V O. Now, divide the curved portion of the profile J L of the elevation into an equal number of parts, as shown by the small figures. From the small figures, and at right angles to I J of the elevation, draw lines through the plan view, intersecting the miter line A S, as shown. From the intersections obtained on the miter line A S draw lines parallel to S R, intersecting the miter line R A. Likewise from the intersections obtained on R A draw lines parallel to R P, intersecting the miter line V P, as shown. For the pattern for the side of the head shown by 2′ in plan, and which will also be the pattern for the side 1′, proceed as follows: At right angles to N S of the plan draw the line E F, as shown, upon which place the stretchout of the profile J L of the elevation, as indicated by the small figures on the stretchout line E F. At right angles to E F, and through the small figures, draw lines indefinitely, as shown, which intersect with lines of corresponding numbers drawn at right angles to N S from the intersections on the miter line A S. Trace a line through these intersections, as shown by Y Z. Extend the line M N of the plan upon the pattern, as shown by W X. Then will W Y Z X be the pattern for the sides shown in plan by 1′ and 2′.

For the pattern of the front shown in plan by 3′ proceed as follows: At right angles to P R of the plan draw the line G H, upon which place the stretchout of the profile J L of the elevation, as shown by the small figures, and draw the usual measuring lines, which intersect with lines of corresponding numbers drawn from the intersections on the miter lines V P and R A, at right angles to P R. A line traced through these intersections, as shown by W′ and Z′ X′, will be the required pattern for the front of head shown in plan view by 3′. As the angles N S A, A R P and R P V are the same, it is self evident that the miter cut for each of the angles will be alike, and in practice the pattern for the front could be obtained by

using the pattern for the side, in the same manner as has been explained in connection with Fig. 138. Before obtaining the pattern forming the transition from the square to the octagon it will be necessary to obtain a profile through A B in plan, for which proceed as follows: At right angles to R S of the plan draw the line A B, cutting the corner A of the leader, as shown. As the distance A B, or the distance at right angles to R S, is less than the distance U N, or the distance at right angles to S N, a profile will have to be obtained through the line A B from which to obtain the stretchout in developing the pattern. As the hight of all points in this piece is the same, draw lines parallel to I J of the elevation, through the small figures in the profile J L, producing them indefinitely as shown. Transfer the intersections obtained on the line A B in plan to any horizontal line beneath the profile, to be constructed as shown by A′ B′. From the points on A′ B′ erect vertical lines intersecting lines of corresponding number previously drawn, as shown from J′ to L′.

For the pattern of the transition piece shown in plan by 5′ proceed as follows: At right angles to R S of the plan draw the line C D, as shown, upon which transfer each separate space from the profile J′ L′ upon the line C D, as shown by the small figures 1′, 2′, 3′, etc. At right angles to C D, and through the small figures, draw lines indefinitely, as shown, which intersect with lines of corresponding numbers drawn from the miter lines A R and S A at right angles to R S. Lines traced through these intersections, as shown by W′ Y′ and X′ Y′, will be the required pattern for the two transition pieces shown in plan view by 4′ and 5′. Laps can be allowed on the pattern for front and sides, thus avoiding laps on the transition pieces and on the flat back shown in plan by M N. For the pattern of the flat back indicated by M N in plan view, simply prick through the elevation I J L K, Fig. 140, direct upon the metal, which completes the entire patterns required. Fig. 141 shows a perspective view of the leader head. The laps soldered against the back of the head are indicated at A.

The flanging of the square and octagon tubes as required is done upon the hatchet stake or by means of a flat pliers.

The same method is employed for forming the molding B D, shown in elevation in Fig. 138, as that described in connection with Fig. 137. The bends 2 and 3 are made upon the hatchet stake and placed upon the former S, Fig. 137, in the position shown by X^1 A^2. Hold X^1 firmly against the former S and press down A^2, which will form the cove shown by X^1 B^2. The following sharp bends, shown in the profile B D in Fig. 138 by 6, 7, 8, 9 and 10, are made upon the hatchet stake by means of a mallet.

After the heads have been accurately formed to their respective profiles the laps are bent off with flat pliers, square or octagon, according to the plan of the head. Cut a small octagon bevel from heavy sheet iron, to be used in tacking the parts together. Tack with solder the various parts, beginning with the front and ending with the back. Now look down over the members of the molding so as to see if they are accurately placed with regard to one another and that the head is not lopsided. Then solder water tight and put in the pipe last.

There is always a risk in using the bevel that it may be moved in some way or other, thereby changing the angle, and if not seen in time often causing the work which was done with the bevel to be taken apart. To avoid this, any old piece of metal can be placed under the angle required and pricked through upon the metal and cut out with the shears; the angle will then be stationary and no risk will be taken.

MAKING A CIRCULAR CONDUCTOR HEAD

In Fig. 142 is shown the plan and elevation required for obtaining the patterns for a circular leader head. Let A B C D represent the front elevation. Draw the center line E X′, extending it indefinitely, as shown by E K. At right angles to E K draw the line X Y, intersecting the center line E K at M. With M as center strike the circle J, representing the plan of the pipe. From the numbered bands in the profile B D in elevation drop lines parallel to E K, intersecting the line X Y at points Y″, Y′, Y, O and M′. With M in the plan as center, and with radii M M′, M O, M Y, M Y′ and M Y″ describe arcs, as shown, intersecting the back of head G H, which lies against the wall line U, V, thus completing the plan of the head. It should be understood that the front elevation in Fig. 142 indicates the section through X Y in plan, and would not be the pattern for the back of the head shown by G H. The length of G H being less than a section on X Y, a special pattern for the back must be obtained. For this pattern proceed as follows: Space the profile B D in front elevation, Fig. 142, into any convenient number of parts, as shown by the small figures 1, 2, *d*, 3, 4, 5, O, V, 6, 7 and 8.

Now at right angles to the center line E K, Fig. 142, draw lines from the points of intersections on the profile B D, as shown; from these same points in the profile B D, Fig. 142, drop lines parallel to the center line E K, until they intersect the

center line X Y in plan. Then with M in plan as center and with the various intersections on the center line X Y as radii describe arcs intersecting the line G H in plan. It will be noticed that the intersections obtained on the line G H in plan are numbered to correspond with those on the profile B D in elevation. Referring to Fig. 143, draw any line, as G′ H′, upon which transfer the intersections obtained on the line G H in plan in Fig. 142, as shown by the small figures in Fig. 143.

At right angles to G′ H′, Fig. 143, and from the points indicated by the small figures, draw lines upward, intersecting lines of similar numbers drawn from the

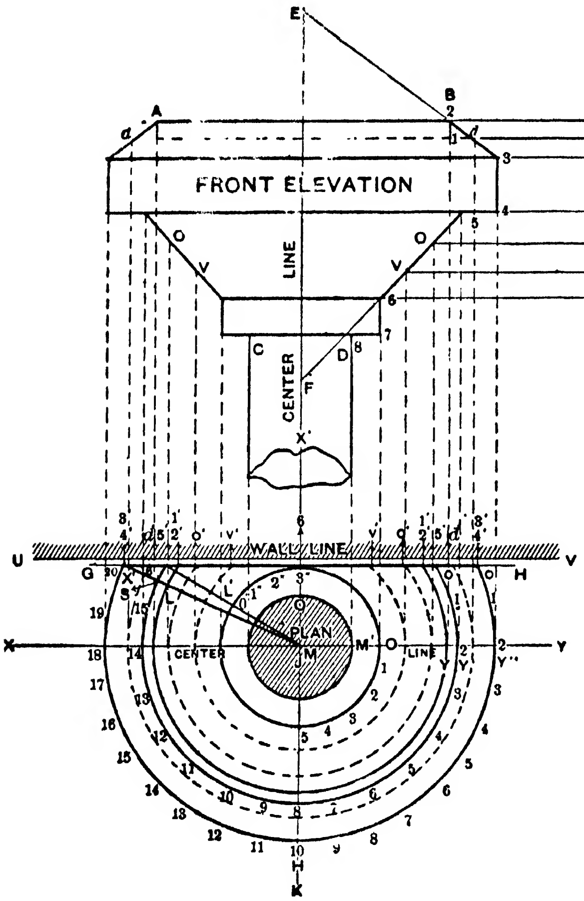


Fig. 142. Plan and Elevation of a Plain Round Leader Head

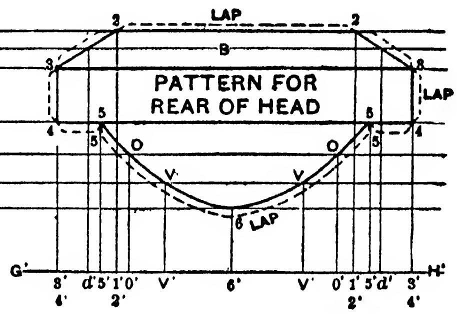


Fig. 143. Pattern of Rear of Leader Head

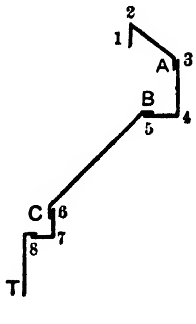


Fig. 144. Method of Constructing Laps or Flanges

profile B D. A line traced through these intersections, as shown by 2, 3, 4, 5, 6, 5, 4, 3, 2, will be the required pattern for the back of the head. Laps are allowed for soldering, as shown by the dotted lines. Before obtaining the patterns for the flaring strips draw a profile, as shown in Fig. 144, which shows the method of constructing the flanges. To develop the pattern for the flaring strip, shown from 2 to 3 in the profile B D, front elevation, Fig. 142, produce the line 2 3 until it in-

tersects the center line E X′, as shown at E. Now, with A, Fig. 145, as center and E 3 of the elevation as radius, describe the arc D B, Fig. 145. Now divide the arc Y″, shown in plan, Fig. 142, corresponding to the point 3 in elevation, into an equal number of parts, as indicated by the small figures 0 to 20. Transfer these 20 divisions to the arc D B, Fig. 145. Draw a line from D to the center A and from A to B, as shown. Now, with E 2 of the elevation, Fig. 142, as radius, and A of Fig. 145 as center, strike an arc indefinitely. From the point 20 in plan draw a line to the center M, intersecting the arc Y, as shown at L. Then will the distance from L to 1′ 2′ in plan indicate the distance of its intersection with the flat back from the point L in the plan. Transfer the distance L 2′ 1′ to the pattern in Fig. 145, as shown on either side from L′ to 1′. Draw lines from D to 1′ from 1′ to the center A, from A to 1′ and from 1′ to B.

Set off the widths of the flanges 2, 1 and A of Fig. 144 upon the lines A D and A B extended upon either side of the pattern, Fig. 145, as shown. With A

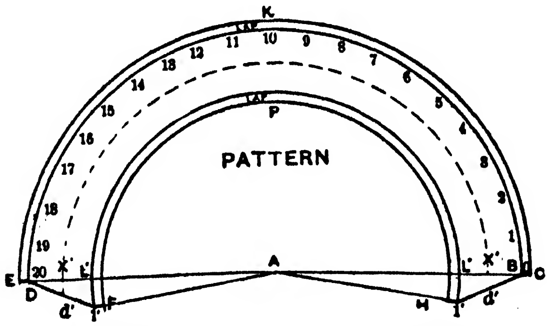


Fig. 145. Pattern for Flare Shown by 2 3 in Elevation, Fig. 142

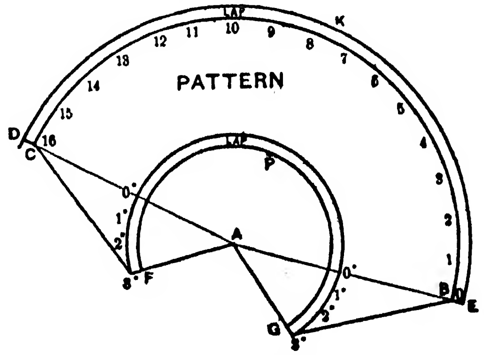


Fig. 146. Pattern for Flare Shown by 5 6 in the Elevation, Fig. 142

E and A F in Fig. 145 as radii, describe the arcs, as shown. Then will H, 1′, B, C, K, E, D, 1′, F, P be the pattern for the flaring strip shown in elevation from 2 to 3. For the pattern of the flaring strip shown in front elevation by 5 6, the same method is employed. Produce the line 5 6, Fig. 142, until it intersects the center line at F. Now with A, Fig. 146, as center, and F 5 of the front elevation as radius, describe the arc C B. Divide the arc Y′, shown in the plan, Fig. 142, corresponding to the bend 5 in the front elevation, into an equal number of parts, as shown from 0 to 16. Transfer these 16 divisions to the arc C B, Fig. 146, as shown. Draw a line from C to the center A, and from A to B. Now with A, Fig. 146, as center, and F 6 of the front elevation, Fig. 142, as radius, describe the arc 3″ to 3″.

From the point 16 in plan draw a line to the center M, as shown by the line 16 M, intersecting the circle O at L′ of the plan. As the circle O is not intersected by the flat back, the distance from L′ to 3″ must be added to the inner circle of the

pattern to make it complete. Divide this portion of the circle into any number of parts, shown by 0″, 1″, 2″ and 3″, and transfer these spaces upon the arc 3″ 3″ shown in pattern, Fig. 146, commencing on the line D A and A B at points 0″ 0″, as shown from 0″ to 3″ on either side. Draw a line from 3″ to the center point A and from A to 3″. Allow the flanges, shown by B and C, Fig. 144, upon the pattern by D E and F G, in the same manner as explained in connection with Fig. 145. Then will D, C, 3″, F, P, G, 3″, B, E, K represent the pattern for the flare, shown in the front elevation, Fig. 142, from 5 to 6.

The next step is to obtain the pattern for the fillet shown by 3 4 5 in the front elevation, Fig. 142. There are two ways of obtaining the pattern when the head

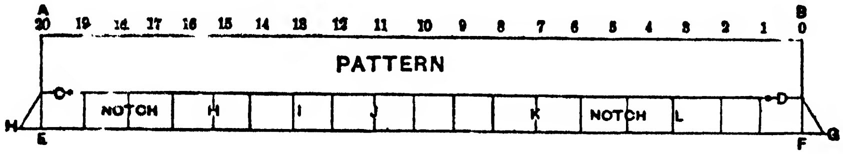


Fig. 147. Pattern for Fillet Shown in Elevation, Fig. 142, by 3 4 5

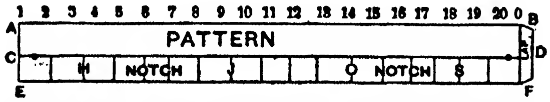


Fig. 148. Pattern for Fillet Represented in Elevation, Fig. 142, by 6 7 8

is made by hand. The first and long way is to trace off that part of the circle shown in plan by 0, 1, 20, 16, 8, 0 upon a piece of metal, and cut out with the shears and solder upon the outside circle a strip of metal as high as shown from 3 to 4 in front elevation. This method is not advisable, as there is too much waste of metal in cutting the circle. The better and stronger way is shown in Fig. 147. Upon any line, as A B, lay off the stretchout of the arc Y″, Fig. 142, corresponding to the bends 3 and 4 in elevation, as shown by the small figures from 20 to 0. At right angles to A B, on either side, draw the lines B F and A E, upon which lay off the width of the fillet and its under side, 3 4 5, Fig. 144, as shown by 20 C E and O D F. Draw a line from C to D and from E to F, extending the line E F in the direction of H and G. Referring to the plan, Fig. 142, the line 20 M intersects the arc Y′, as shown at S. Then will the distance S 5′ in plan represent the increased distance on the line 5 necessary to meet the flat back. Transfer the distance S 5′ to each end of the line E F, Fig. 147, as shown at H and G. Draw the lines H C and G D. Then will A B G H represent the pattern for the square fillet shown in the front elevation, Fig. 142, by 3 4 5. This method gives no waste whatever, as the pattern is straight, the lower portion being notched, as

shown in the pattern. The dots shown on the line C D, Fig. 147, indicate the bend 4 shown in elevation.

Fig. 148 shows the pattern for the square fillet 6 7 8 of Fig. 142. The same rule is followed as explained in connection with Fig. 147. This completes the entire set of patterns required for the circular leader head shown in Fig. 142.

Referring to the section shown in Fig. 144, it will be seen that the top flare, 2 3, has two laps or flanges shown by 1 and A. The pattern for the flare, 2 3 is shown in Fig. 145. Roll this pattern upon the blowhorn stake until it has the required curve indicated by the arc Y″, Fig. 142. Now turn the two laps or flanges shown in the pattern, Fig. 145, in the turning machine to the required angle shown by 1 and A, Fig. 144. If the turning machine does not bring the flanges to their proper angles place them upon the bottom stake and with the use of the mallet bring them to their proper angles. The pattern shown in Fig. 146 is formed in the same manner as explained above. The laps on the pattern for rear of head, shown by the dotted lines in Fig. 143, can be bent to the required angle by means of the flat pliers or upon the hatchet stakes with the use of a mallet.

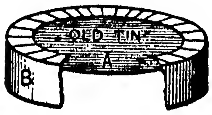


Fig. 149. Method of Placing a Profile Inside of the Notched Fillets so as to Obtain a True Circle

The pattern for the square fillet shown in Fig. 147 is bent upon the line C D. The bend can either be made in the folder, the cornice brake, or by means of the hatchet stake and mallet. The notches, indicated by I, J, K, etc., shown in the pattern, Fig. 147, are cut with the shears after the bend is made. A mistake often made by workmen is to first roll this pattern to its required circle, then notch with the shears and bend over with the flat pliers, thereby failing to obtain a sharp corner. The better plan is to make the bend first, then notch the flanges required, letting them overlap each other as the bending is done. For forming the pattern shown in Fig. 148 the same method is employed. In Fig. 149 is shown the method of placing a template inside of the notched fillets so as to obtain a true circle. As will be noticed by referring to the figure, A represents a template cut from an old piece of tin or other metal corresponding in shape to the circle required. B represents the notched fillets drawn around the circle A. Draw the fillet B, Fig. 149, tightly around the template A and solder the seam.

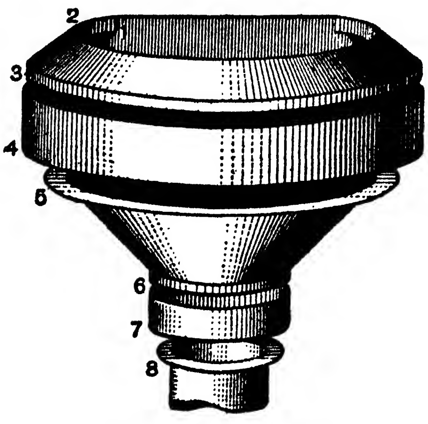


Fig. 150. The Leader Head Ready to be Soldered Together

SECTION V

(Pages 543-552)

GUTTERS AND ROOF OUTLET LAYOUTS

Practical Sheet Metal Work and Demonstrated Patterns

ROOF OUTLET FOR INSIDE DRAIN PIPE

Fig. 1 is a sectional view of the outlet to connect to the inside drain pipe. A is the cast iron soil pipe, and this applies to screw pipe systems also, except that ferrule B, which is a brass sleeve, would be threaded instead of, as in this case,

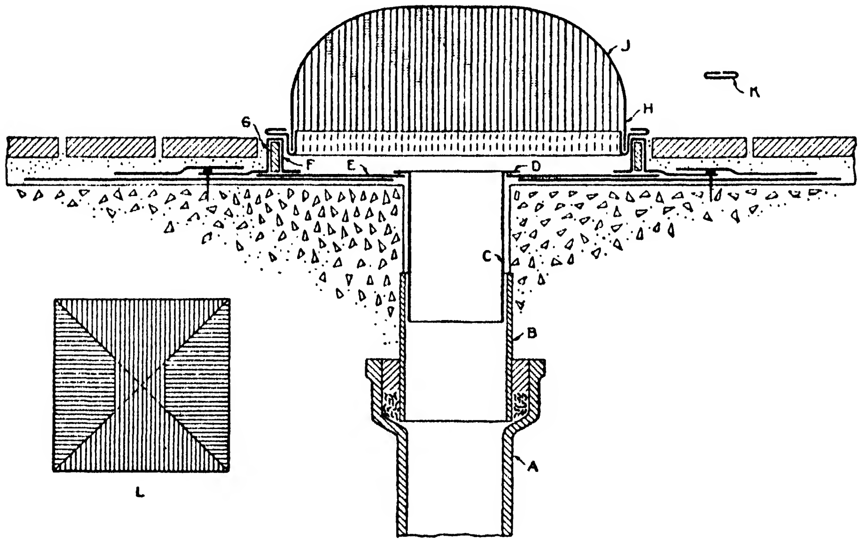


Fig. 1.—Details of Outlet to Conductor Pipe

caulked in. A copper tube C, is heavily soldered to B. This tube is generally in place before the outlet is set on roof so a hole is cut in box just big enough to admit the tube.

The tube is trimmed within, say $\frac{3}{8}$ of an inch of the bottom of outlet, flanged, at D, and carefully soldered, for, despite numerous attempts to devise other methods this still prevails. It is obvious that this is the weak point and on highest grade jobs cast copper outlets with the tube integral are required.

The outlet box consists of a square sheet of copper, E, and the sides, F, which are bent as shown and soldered to the sheet E and reinforced with a core of band

iron, G. The box is nailed to the ash concrete of the roof through the waterproofing and made watertight with more felt and tar. Then flat tiles of roof are laid in cement.

The strainer of the outlet is made of four sides formed, as shown at H, and the basket part consists merely of strips of copper bent, as indicated at K, and shaped to fit the desired contour. The diagram at L, which is a plan view, gives the idea of the manner of assembling the strips having the hips of wire. The strainer is usually just set in the outlet but if required can be hinged, by wiring, H, with sheet metal hinges and soldering hinges to outlet.

CAST COPPER ROOF DRAINAGE HEAD

There always has been considerable trouble with the conventional inlet of sheet metal to the rain-water conductor. The manner of connecting the tube to

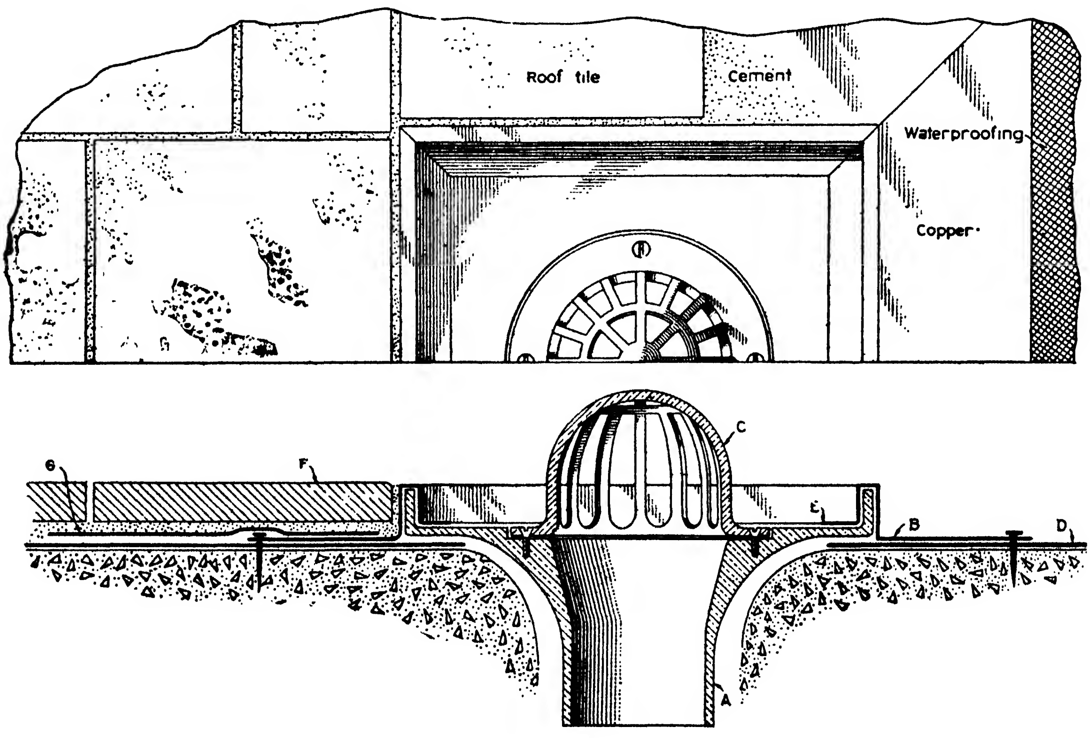


Fig. 2.—Construction and Method of Installing Roof Drainage Head

the inlet certainly violates the teachings of experience in roofing, which tells us that all seams shall be made so as to have the water flow over the seam. In the

majority of cases, after carefully seeing to it that all seams are as stipulated, we insert the tube in the box or gutter with a flange turned out against the water coming from the entire roof. When this flange tears from the outlet, for this is within the range of possibility, the water soaks through this broken connection into the building.

Architects now realize that what should be the strongest part of the roofing is the weakest and specify that the tube shall be integral with the inlet box. About the only way to accomplish this is to have them cast in one piece. The accompanying drawing Fig. 2 shows how a cast copper or brass inlet, or outlet as some call them, is applied to roofing.

The box and tube are shaped to have ample strength at the connecting point and the sides are made to act as a guard for the flat tiles F or the gravel of the roofing.

A sheet metal flashing, B, is bent to fit over these sides and turned 6 in. out on the roof. This flashing is heavily soldered to the outlet box at E. The box is set in place and the flashing nailed to the ash concrete through the waterproofing D and made watertight with more felt and tar, G, after which the tiles are laid.

The strainer C is also cast copper and secured to the outlet box by screws as shown. Most any design will do for this strainer, only bearing in mind that the apertures shall be small enough to intercept objects as small as a pebble.

Connecting this outlet to the drain pipe is properly within the province of the plumber. But, while this tube A can be either caulked direct to the cast iron conductor pipe or a thread cut in it for screw connection, it is suggested that a flexible rather than this rigid connection be used, such as a lead elbow with wiped joint to the tube A.

After the pattern is made these outlets would not be costly in comparison with the unsatisfactory sheet metal ones, when considering the fact that on buildings where the best roofing is required they give complete assurance of no leaks by bursting tube or connections.

WATER SPREADER FOR STEEP ROOF

It is often the case that the rain water from an upper roof is drained through leaders on to a lower roof. When the latter is very steep and the upper roof has a large surface the rain water in a storm or shower rushes through the leader and out of the elbow, shown at C, Fig. 3, and in some cases the force of the rush not being broken it is apt to flow or spray over the gutter D, shown in the side view.

To avoid this and to break the rush of the water there is shown in Fig. 4 a view of a water spreader with dimensions. The spreader is riveted on a sheet of tin, copper or sheet iron, as required. If the roof is of tin or copper a lock is edged on

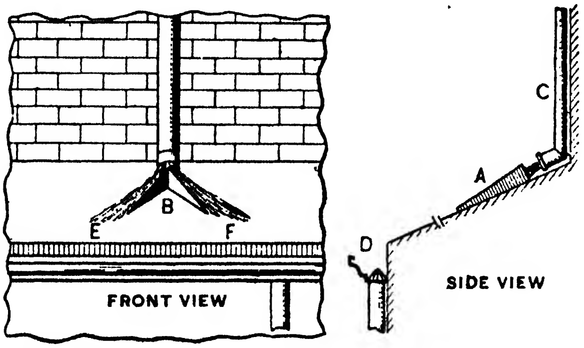


Fig. 3.—Water Spreader for Steep Roof. Front and Side View of Water Spreader

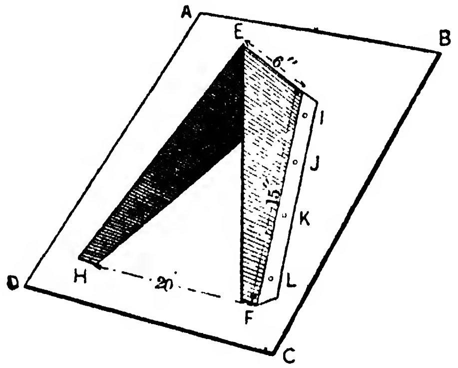


Fig. 4.—General View of Water Spreader as it would Appear on a Steep Roof

to the sheet A B C D and laid in with the courses, while if the roof is of slate or wood shingles the spreader is fastened to heavy galvanized sheet iron and slated in with the courses. E F H represents the spreader, being 6 inches high, 15 inches long and having 20-inch spread, and is riveted at I J K L on each side. In Fig. 3 is shown the method of placing the spreader in position, A being the spreader in side view and B in front view. The water rushing through the leader C is cut by the spreader, throwing the water in either direction at E and F, then flowing into the gutter D.

ANOTHER WATER SPREADER

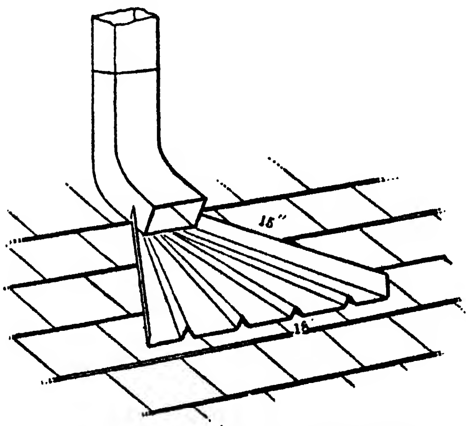


Fig 5.—A Water Spreader for Roofs

Another simple and inexpensive spreader, as shown in Fig. 5, of copper or galvanized iron may be made on any brake or bending machine of a width and length to suit the conditions. The effect is to spread the water out in a thin sheet, and the shape of the spreader is such as to be proof against injury by ice forming on it. By its use all trouble from water penetrating the spaces between the slates or shingles is avoided.

ROOF WITH SINGLE LEADER

A few suggestions regarding a gutter for a roof like Fig. 6, are that the gutter should be almost level for some distance from the starting point and then made to

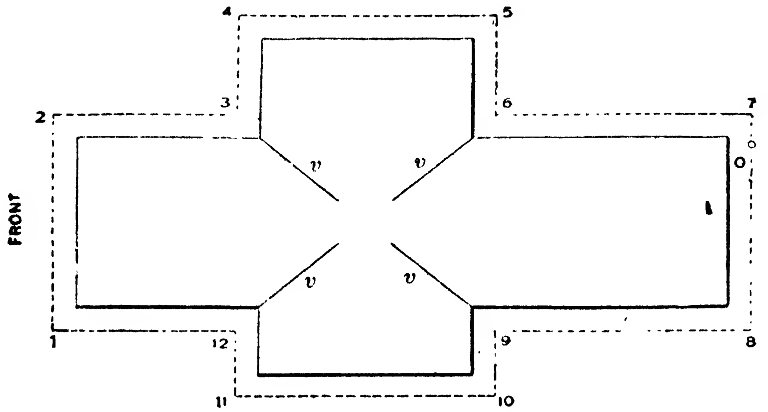


Fig. 6.—Roof with Single Leader Pipe. Plan of Roof.

incline toward the outlet, this last half being enlarged if possible. The inside miters, as 3 or 6, should be made rounding or "octagon," as shown in Fig. 7, which would help the flow of water to a considerable extent. In this figure A B C D E F G represents the gutter in plan and J K in profile. By placing the gore piece as indicated by F H E the trough would be wider at the bend. It is suggested that

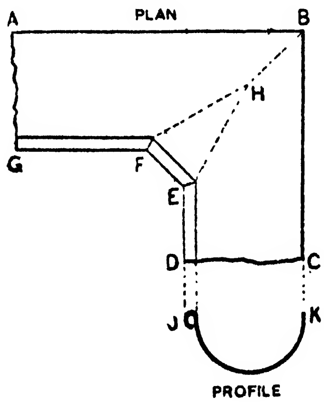


Fig. 7.—Proposed Form of Inside Miter

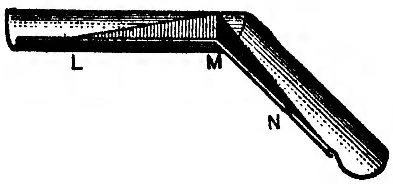


Fig. 8.—Guard for Inside Miter

upright pieces of tin or guards be soldered to the bead of gutter at the inside miters 6 and 9. The pieces, as shown in Fig. 8 by L M N, could extend each way from 18 inches to 2 feet and be 2 or 3 inches high at the center M, tapering each way to

L and N. If desired the miters at 6 and 9 could be made as indicated in Fig. 7 and provided with guards similar to Fig. 8, being bent so as to conform to the shape shown by G F E D of plan.

AN ESSENTIAL FEATURE IN GUTTER CONSTRUCTION

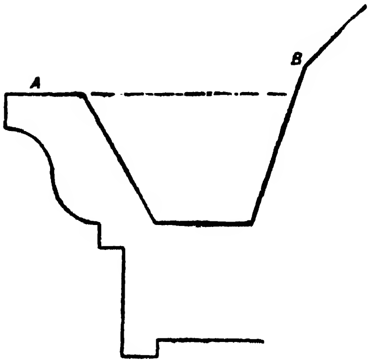


Fig. 9.—An Essential Feature in Gutter Construction

In any gutter it is within the range of possibility of the outlets becoming clogged from various causes. Hence it is necessary to bear this in mind when designing gutters, etc., and have them so constructed that in the event of the outlet becoming stopped up the water will flow over the face of the gutter or cornice and not back up on the roof and under the slates, shingles or cap flashing and into the building. In short, the rule to be followed is to have the point A, of Fig. 9, lower than the point B.

INSIDE MITER OF A GUTTER—A GORE PIECE

It is obvious that a considerable flow of water occurs in the valley of a roof and if this water is discharged into the internal angle of a gutter it is apt to splash over the sides of the gutter, the more so if the roof is very steep.

And as the water flowing in the gutter makes the turn in an inside miter it very often, owing to the sharpness of the turn, banks and runs over the gutter.

Therefore if we make the miter as we would a three piece elbow an easier turn is provided and also a gutter wide enough at this point to take care of all the water flowing from the valley.

The diagram Fig. 10, shows an eave trough with a right angle inside miter and the gore piece A. The size of this gore piece is a matter of choice and the same principle of obtaining patterns applies for any angle.

The method of developing the patterns is to place the profile of the gutter as shown, and in its proper position the plan. Having decided on the size of the gore the line B D is drawn with the 45° triangle and angles B and D bisected as shown.

For other than a right angle miter the correct position of the line B D is found by bisecting the angle and drawing B D perpendicular to the bisecting line.

As in many cases of pattern cutting the miter lines can be arbitrary, providing no rules of geometry are violated. In this instance the bisecting lines of angles B and D were terminated on the bottom line of the profile as C and E thereby realizing the plan of the gutter miter.

The profile is now divided into convenient spaces as 0 to 19 and these points dropped to the miter lines as shown.

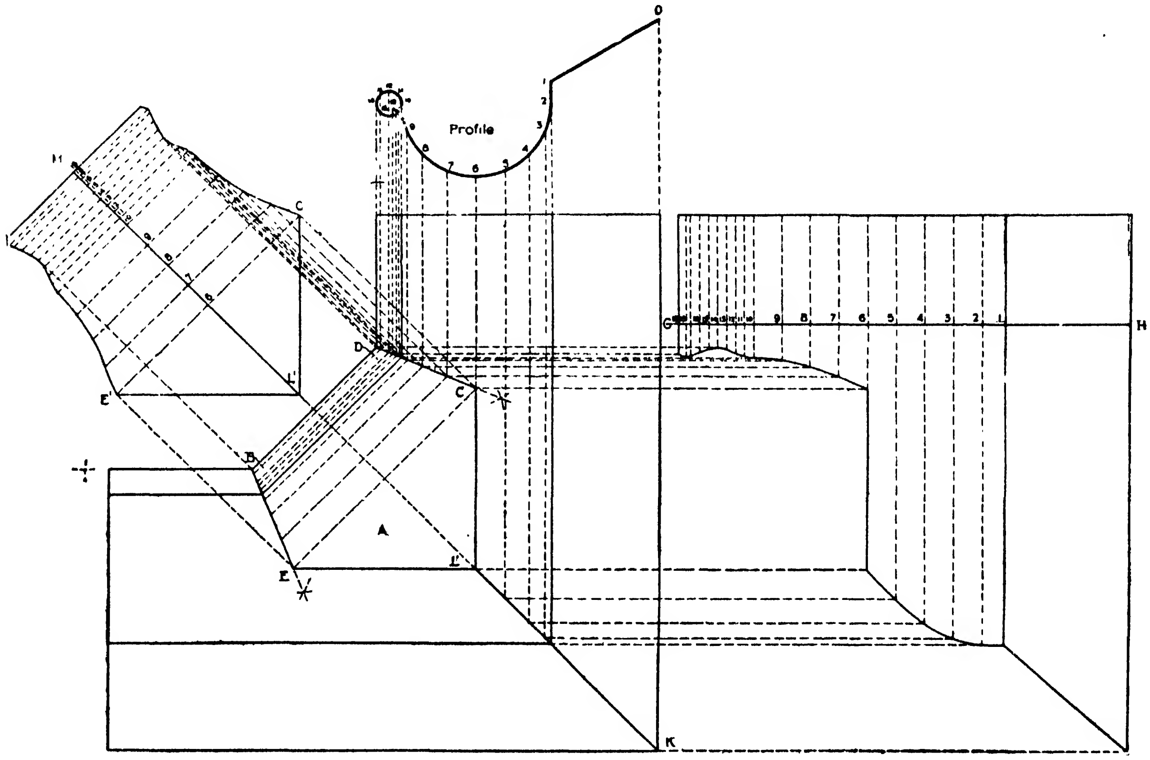


Fig. 10.—Inside Miter of a Gutter—A Gore Piece

On the line G H place the stretchout of the miter profile and project lines from like points on the miter lines as is customary. Then will J be the pattern of the gutter.

Extend the line K L to M, and on this put a reproduction of the triangle piece of the gore E C L as E^1 C^1 L^1, and call line E^1 C^1 number 6. Then from this on line L-M, place the rest of the stretchout of profile to 19, and from miter lines draw lines to intersect like numbered lines which will give the pattern of the gore A.

When allowing the laps have them on the patterns so that the water will flow over the joint and not against it.

FALSE BOTTOM FOR GUTTERS

All the gutters must obviously have a pitch or fall to the outlet and in the hanging type, such as eave trough, this fall is perceptible from the ground. Often if the fall is pronounced it is an eyesore to observers.

To overcome this the molded face styles are made level throughout and a false bottom soldered in which has the necessary fall to the outlet. Considerable

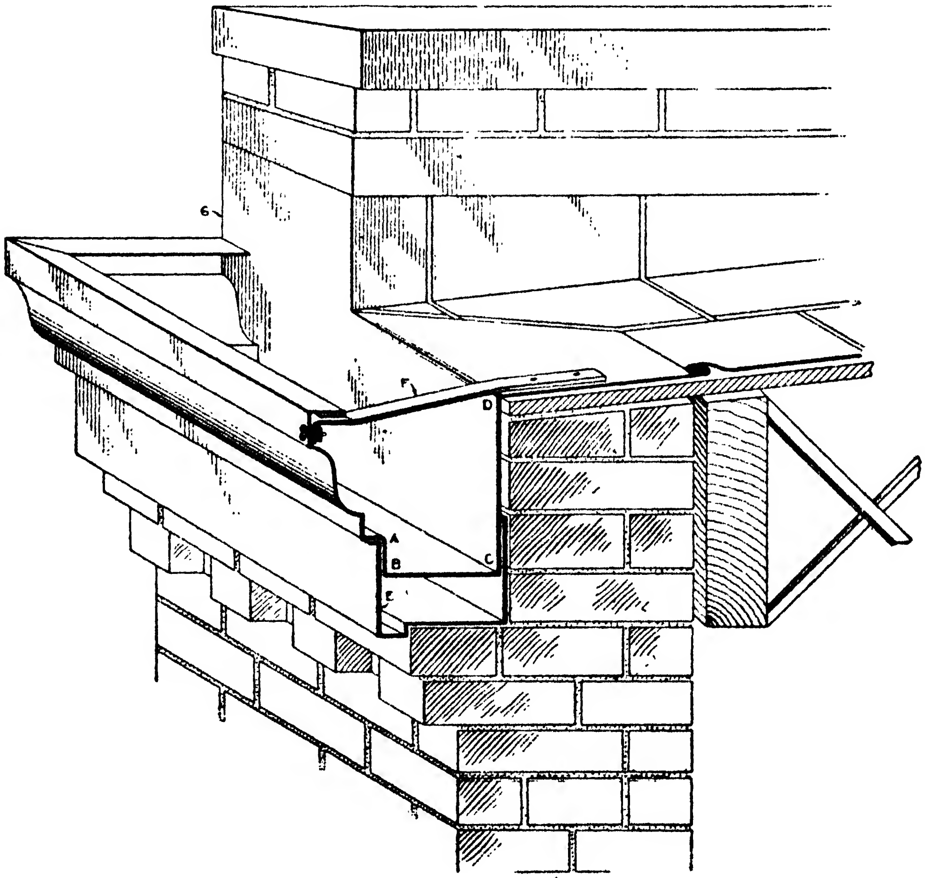


Fig. 11.—Details of a Gutter with a False Bottom

trouble is experienced with these bottoms owing to their breaking from the sides of the gutter despite rivets and soaking in the solder.

Inasmuch as these gutters are intended to be ornamental, Fig. 11 illustrates how this ornamentation can be enhanced by extending a few of the stretcher courses of the brick work and by alternating the bricks of the header course one in one out, an appearance of dentil blocks is obtained.

The gutter proper can have the required pitch in the vertical members A B and C D, and the fascia piece E made separate and with a drip as shown. This fascia piece is soldered to the gutter and as gutters are usually made of heavy material, this fascia piece can be one or two gauge lighter.

At the lowest point or outlet the bottom of the gutter will be down to the horizontal line of the fascia piece which rests on the brick work. The outlet tube is put in and soldered in the customary manner and would either connect with a leader on the outside or the inside of the wall.

The braces F are of galvanized or tinned band iron ⅛ × 1-inch stock, bolted to the front part of the gutter and riveted to the roof flange of gutter as shown. These rivets are soldered watertight on the under side. If, instead, it is specified that these braces be attached after the setting of the gutter and nails driven through to the roof sheathing, then the entire brace must be soldered to the roof flange of the gutter to prevent leaks through the nail holes. These braces are made all alike and spaced 2 feet apart.

The gutters are made in a length on the crown line from the outer edges of the fire or battlement walls G. At the inner lines of the walls the roof flange of the gutter is cut and flattened out and forms a flashing which goes up and under the cap flashing that was built in with the wall. The wall flashing connects with this flashing of the gutter as shown by the illustration.

Should the wall flashing be very high at the outer edges of the walls, use some roofer's paint skin and secure it to wall with hooks to keep rain from blowing in behind the flashing at G. A much better method would be to step the flashing into the brick work.

BRACES FOR EAVE TROUGH

The illustration herewith, Fig. 12, is a sectional view showing how eave trough can be fastened. A represents the roof boards, which should not be less than 1¼ inches in thickness, and grooved out as shown, so as to admit the bottom brace B. This brace is made from 3-16 × 1¼-inch band iron, screwed to the roof boards with screws B′ B′. After all the bottom braces have been fastened, the gutter C is laid in the bottom braces and securely pressed into them, after which the top brace D is bolted to bottom brace B, as shown at E. In this manner the gutter is held in position by the bolt E. The top brace is screwed to the roof boards, as shown by F, which at the same time holds the flange of the gutter in position,

shown by C′. This flange of the gutter C′ should extend up high enough under the slate to insure a tight job. H H indicates the first slate and shows how the slate should overlap the screws so as to avoid a leak.

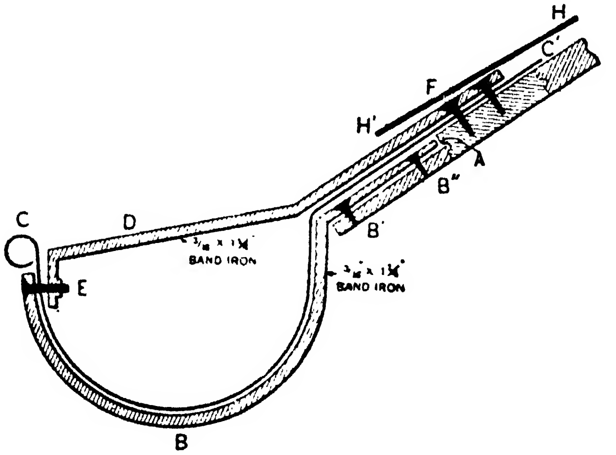


Fig. 12.—Fastening Eave Trough

In bending the top and bottom braces proceed as follows: Measure off the length of the brace required, which can be done by taking a strip of tin and laying it around the outside of the gutter, as shown in Fig. 12. Cut off as many pieces of band iron to the required length as there are braces required. In forming the bottom braces roll them through the stove pipe former or roller until they have the required circle, after which place the brace in a vise and bend off the flange to the required angle, as shown at B′, Fig. 12. One-quarter inch holes are now punched by hand or machine, where shown, so as to admit the bolts and wood screws. The top braces are made in the same manner and ¼-inch holes punched in them for bolts and wood screws. When this gutter is completely finished it will sustain quite a pressure. The snow sliding from the roof obtains quite a hold in the gutter and the braces prevent the gutter from breaking down.

COMPLETE INSTRUCTION ON A ROOF OR SNOW GUARD GUTTER

In Fig. 13 is shown a section of a roof or snow guard gutter, also the method of slating it. To give a better explanation of this diagram the method of starting a slate roof will be explained. As this is a little out of the line of cornice work, it is better if we understand it in case the slate roofer would desire to know how many courses he should slate before the gutter is put on. Before starting a slate roof the roofer should see that a cant strip is nailed about 1 or 2 inches above the eave line of slate, as shown at F, Fig. 13. This strip should be about ¼ inch in thickness and 1½ inches wide, the ordinary plaster laths being satisfactory. If the slates used are 8 × 16 inches in size, the first course should be laid the

16-inch way, or, in other words, the length of the slate should be laid parallel to the eave line of the roof. The second course and all others should be laid the 8-inch way. In laying the 8 × 16 inch slates it is usual to lay them 6 inches to the weather, by which is meant the second course will overlap the first 10 inches and the third course will overlap the first 4 inches. Let E, in Fig. 13 represent the leader, which we desire to place in the position as shown. The place of the leader being decided upon at once gives the position where the lowest point of gutter will be placed and the number of courses of slates required. Referring to Fig. 13, it will be seen that the slater must put on four courses of slate, counting the course under eaves (if the leader was placed higher or lower the number of courses of slates would be more or less, respectively). After the lower four courses of slates are in place the slater must stop until the gutters are set. It is usual to give about 4 inches pitch to about 20 to 25 feet of gutter.

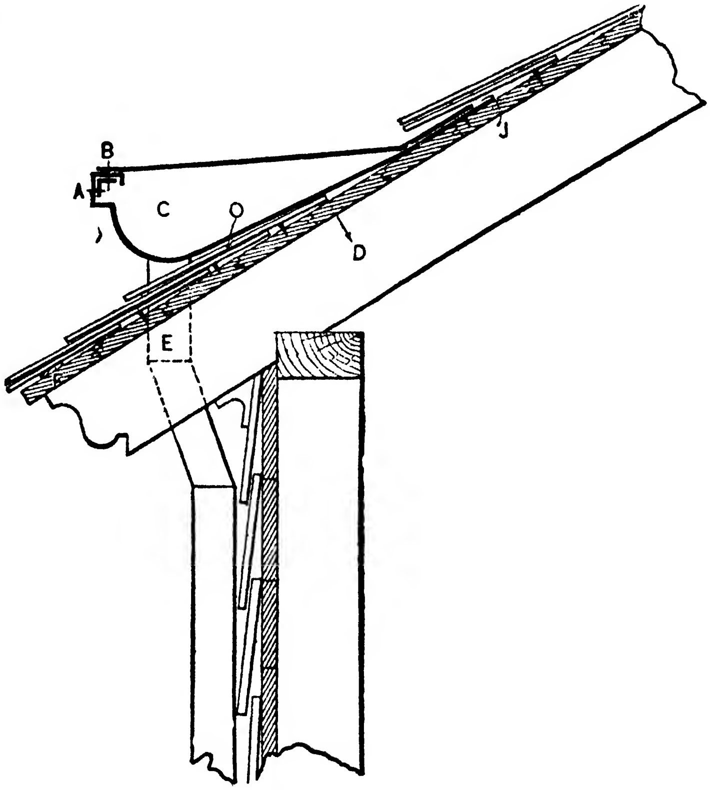


Fig. 13.—Section of Snow Guard Gutter, Showing Method of Slating

The style of gutter shown in Fig. 13 has an angle iron of $\frac{1}{4} \times 1\frac{1}{4} \times 1\frac{1}{4}$ inch in size and lighter, bolted through the galvanized iron gutter and top brace. The top braces are usually bolted about 30 inches from centers, and are made of 3-16 or $\frac{1}{4} \times 1\frac{1}{4}$ inch or 1-inch band iron respectively, and are galvanized after being made.

In putting up this form of gutter the angle iron is left out until the gutter has been placed in its proper position on roof and tacked with a few roofing nails, as shown by A and B, Fig. 16. After the gutter is set to the right pitch the angle iron is pressed up into the inside top edge of the gutter and held in position with a few hand vises, as shown in Fig. 14, until the bolts are inserted, after which the hand vises are removed. If a punching machine is not at hand, the holes in the angle iron

and the top braces can be punched by hand by having a female die placed on a solid block of iron or wood, so that when the punch is being driven from the top there will be no springing.

The holes in the top braces to receive the wood screws can be countersunk by means of a breast drill if a machine is not at hand. The breast drills, including the punches and dies, can be purchased of any dealer in tinners' and cornice makers' tools. After the top braces are bolted to the angle iron at B, Fig. 13, a wood screw or two is screwed through the top brace at J. The slate roof is then started again, in the same manner as described for the eaves.

If the roof covering, as shown in Fig. 13, were to be of shingles the same rule would be followed as for slate. If tin were used, then tin up the roof as far as shown at D, Fig. 13, and set the gutter in its right position. As the gutter is to

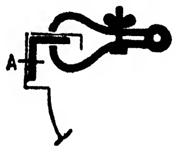


Fig. 14.—Angle Iron held in Position with Hand Vise

Fig. 15.—Lap on Corrugated Iron Roof

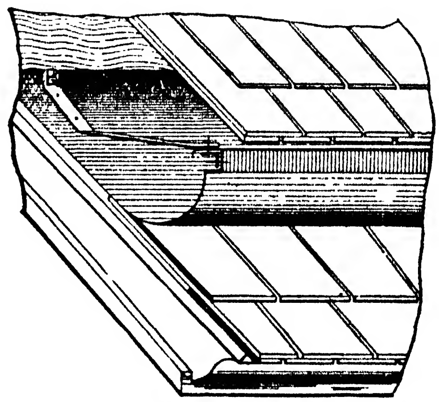


Fig. 16.—Perspective View of Roof or Snow Guard Gutter, Showing Angle Iron and Brace

set to a given pitch, the upper edge of the gutter J, Fig. 13, would be cut on a straight line struck by means of a chalk line and chalk, and then a lock attached, as shown at J K, Fig. 20. The tin is now locked on to the flange of gutter and the roof tinned up.

If the roof were of corrugated iron, the sheets would be allowed to extend up as far as D, Fig. 13. The gutter would now be set to the proper pitch, on the top flange of which a lock would be made, as before described, it not being necessary in this case to cut the flange straight This lock would prevent the snow from driving up under the corrugations. In laying a corrugated iron roof as much lap should be given as is shown in Fig. 15. In tile roofing the same method would be employed as described for slating.

It is very advisable, if the roof covering is of slate, tile or shingles, to lay a sheet rubber cushion, not less than 3-16 inch in thickness, between the bottom of the gutter and top of the slate, tile or shingle, as shown at O, Fig. 13, to prevent breakage in case a large amount of snow would slide into the gutter. The rubber should be as wide as the part of the galvanized iron flange of gutter that lies against the slate.

Fig. 16 is a perspective view of roof or snow guard gutter, showing the slates in position above and below the gutter, also the angle iron and brace bolted in position, and top brace screwed on the roof board, through the gutter flange.

Let us assume that the gutter is to be connected to a round leader. In Fig. 17 is shown the method of obtaining a watertight joint on roof, with the use of sleeve, tube and leader, and in Fig. 18 the improper method of making a joint, with the use of the tube and the leader only. It is of great importance that this method of putting in the sleeve be understood, as by not using the sleeve a leak is often the result. In Fig. 17, let A represent the sleeve, B the tube and C the leader. It will be noticed that both the sleeve and tube go inside the leader, so that in case the snow drives against the angle E and thaws it must drip inside of the leader; while, as shown in Fig. 18, the snow driving against the angle E when thawing, soaks through the woodwork F and rots it at every storm, because the tube B only connects to the leader C. In Fig. 19 is shown a perspective view of a metal shingle having sleeve attached. These shingles are to be cut to the size

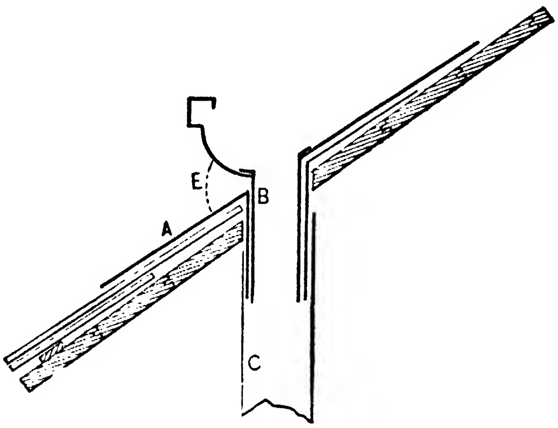


Fig. 17.—Proper Method of Water tight Joint with Sleeve, Tube and Leader

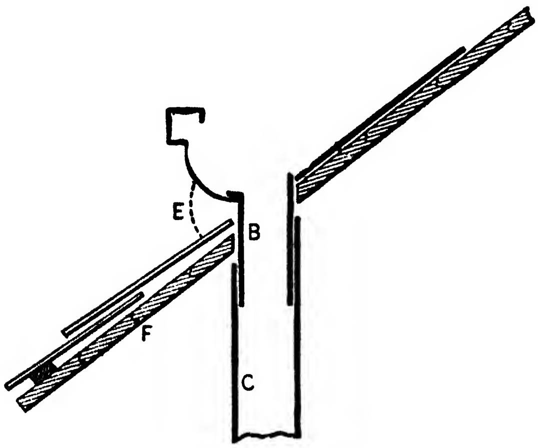


Fig. 18.—Improper Method of Making a Joint

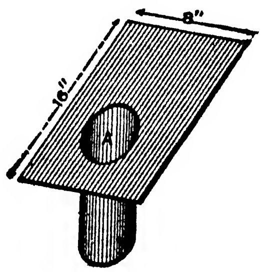


Fig. 19.—Metal Shingle with Sleeve Attached

of the slates used, in this case 8 × 16 inches, and laid in with the course, where the roofs are covered with slate, tile or shingle. The sleeve shown at A, Fig. 19, should be soldered to the shingle where required; that is, just according to how the leader would be situated. In case the leader is so situated as to strike the bottom, center or upper part of slate, the sleeve A would have to be placed accordingly.

At P, in Fig. 20, is shown a shingle with sleeve attached, slated in as required, the leader having in this case cut the shingle in the center. The tube of the gutter passing through the sleeve connects to the leader below at F. In fastening the

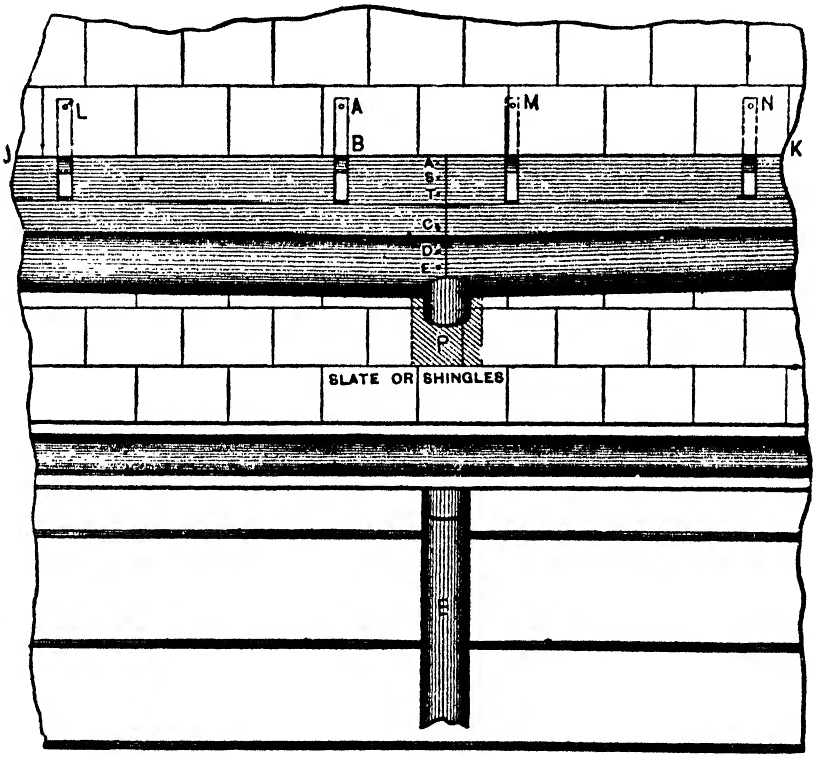


Fig. 20.—Front View of Roof or Snow Guard Gutter

leader F the ordinary hooks are used, which can be made by any blacksmith or purchased of dealers in tinners' supplies. There are different forms of leader hooks and fastenings with ornamental coverings.

In Fig. 20 is shown part of a front view of a roof or snow guard gutter, finished complete, the section of which is shown in Fig. 13. L A M and N represent the braces bolted to the gutter and screwed to the roof; B is the bottom edge of the slate or shingles; C D and E are rivets to reinforce the soldered joint, and

likewise A S and T the tinned or brass wood screws screwed into the roof boards through the flange of galvanized iron and soaked well with solder.

Having understood how the snow guard gutter is to be constructed, the measurement and bevel of roof must now be obtained from the building. Brass and wooden bevels can be purchased from hardware dealers, but a bevel constructed of band iron will answer just as well.

In Fig. 21 is shown what is required to construct a bevel of band iron. Let A represent one of the two pieces of band iron, with a ¼-inch hole punched and countersunk, as shown at D, to receive the rivet, and B the section. C represents a ¼ × 5-8 inch rivet, which is used to rivet the two pieces of band iron together. Care should be taken that when the two arms are riveted together the one is exactly like the other and that the end E is perfectly square.

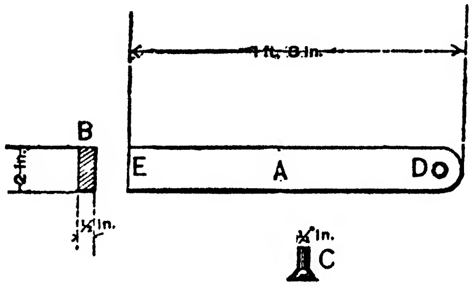


Fig. 21.—Rivet and Band Iron for Bevel

When the bevel is finished and is in use it will look as shown at L, in Fig. 23. Fig. 22 is the front elevation of roof and gutter, also showing the method of obtaining the working measurements.

Let the width of the building on which the gutter is required measure 42 feet as shown, and as the leader P is to be in the center of the building, divide the width by 2, and 21 feet on each side is the result, as shown. The pitch, or fall of the gutter, will come directly over the leader, as shown by X, Fig. 22.

From the point X, Fig. 22, or the lowest point of the gutter, strike a chalk

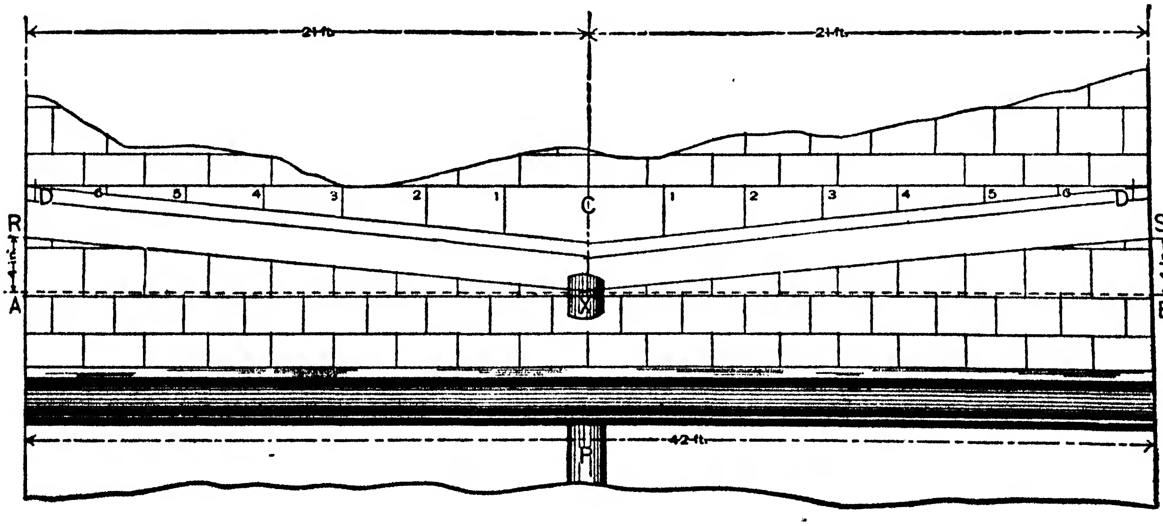


Fig. 22.—Front Elevation of Roof and Gutter

line parallel to the eave line, as shown by the dotted line A B. At right angles to the line A B, on either side, measure up 4 inches, or the pitch of the gutter, on a perpendicular line, as shown by R and S, Fig. 22. Now strike a chalk line, S X and X R, which gives the bottom line of the gutter, shown on the section in

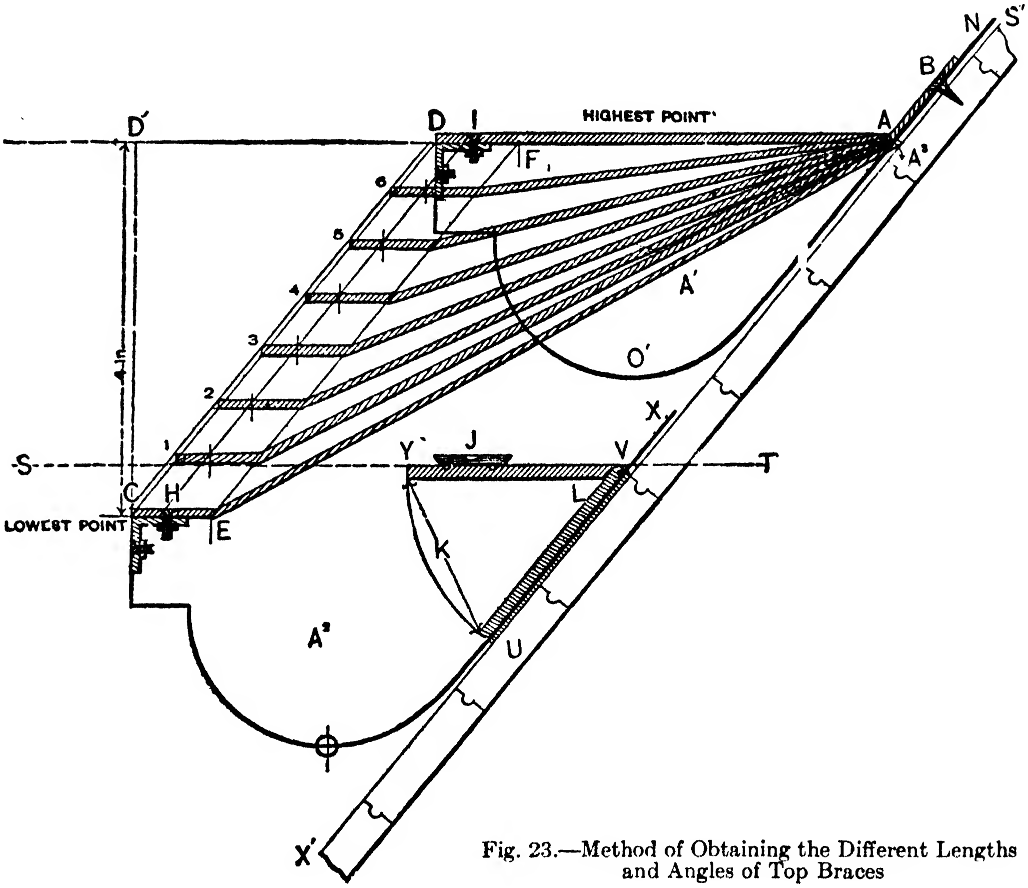


Fig. 23.—Method of Obtaining the Different Lengths and Angles of Top Braces

Fig. 23, at O. The line R X and X S would be struck on the top of the slates, or whatever the covering of the roof may be, and upon this line the bottom line of the gutter would be placed.

Having now obtained the length of each side of the gutter, the next step is to obtain the bevel of the roof. To do so, place the bevel as shown by U V Y in Fig. 23 the arm U V being placed against the roof and the other arm, V Y, being raised or lowered until level, which can be proved by screwing a small spirit level on the arm, as shown at J. Now measure the distance between the arrow points K, and the bevel can be closed and opened again when required to the distance before obtained. This bevel forms the basis of measurements required to construct the different braces shown in Fig. 23.

In setting up work of this kind it is well to make a rough diagram, similar to Fig. 22, showing the braces required and their numbers, also the pitch the gutter is to have, for the use of the mechanic who sets up the work. As the braces are of different lengths (to obtain a straight line, as shown from D to D in Fig. 22), each brace will be numbered in the shop to correspond to the numbers shown on the braces in Fig. 22 by C, 1, 2, 3, 4, etc.

In Fig. 23 is shown the method of obtaining the different lengths and angles of braces. Draw any horizontal line, as shown by S T, indefinitely, upon which place one arm of the bevel Y V; now open the bevel to the length obtained between the arrow points K, as before explained, and draw a line parallel to, and against the arm of the bevel U V, as shown at X′ S′. Then X′ S′ will represent the roof line and S T the horizontal or level line, corresponding to the bevel U V Y. Now draw a section of the gutter, as shown by A′, Fig. 23, care being taken to have the top of the flange of the gutter, as shown at N, high enough above the top of the front of the gutter, so that in case the leader stops up, causing an overflow, the water will flow over the front of the gutter, and not behind the flange N and into the building.

As the pitch of the gutter is 4 inches on a perpendicular line, as shown in Fig. 22, measure down 4 inches from D′ to C, Fig. 23, and draw a duplicate of the section of the gutter A′, as shown by A^2. Then D will represent the highest point of gutter and C the lowest point, as shown. The sections of angle iron, with bolts through the top braces, are shown at I and H. Draw the brace at the highest point of gutter horizontal, as shown from D to A, with an angle attached to screw to the roof board, as shown from A to B. Then draw the brace for the lowest point of gutter horizontal from C to E, or as much as there is flange on the top of the gutter. Connect the points from E to A^3 and add the thickness of the brace, as shown, which in this case is 3-16 inch.

Then D A B, Fig. 23, will represent the top brace D, Fig. 22, and C E A^3 B the center or bottom brace C, shown in Fig. 22. As the pitch of the gutter is 4 inches and the projection of the roof on 4 inches as much as shown from D to D′, Fig. 23, and as there are eight braces required on the 21 feet of gutter, as shown by C, 1, 2, 3, 4, 5, 6 and D in Fig. 22, it is self evident that each brace will be of a different length and angle.

To obtain the different lengths and angles proceed as follows: Draw a line from C to D, Fig. 23, as shown, and divide this line into seven spaces, or as many spaces as there are shown between the braces in Fig. 22. Now draw a line from

E to F, which intersect with horizontal lines drawn from the small figures on the line C D. From the intersections obtained on the line E F draw lines to the corner A. Now add the thickness of the brace, as shown, and draw lines parallel to the horizontal lines 1, 2, 3, 4, 5 and 6, intersecting the line E F, and from these intersections draw lines to the corner A^3. Then the braces C, 1, 2, 3, 4, 5, 6 and D in Fig. 23 will represent the braces used on each side of the gutter of corresponding figures shown in Fig. 22. A line drawn from H to I, Fig. 23, will give the points where the holes are to be punched for the bolts; the angle A B will be the same length on all the braces.

After the braces are bent to the required angle and numbered, they are usually galvanized to prevent rusting; the angle iron also is usually covered with two coats of metallic paint before it is inserted in the gutter.

Fig. 24 is a section of a roof or snow guard gutter, the bends of which have been made square, so as to avoid a confusion of lines in obtaining the patterns; although the principles used are the same no matter what form or shape is taken. To obtain the plan and elevation proceed as follows: Let N S, Fig. 24, represent the line of the roof; C, the highest section of gutter, and D the lowest section. Let A B or H F represent the pitch of the gutter on a perpendicular line and E F the projection of same. Let R S U T, Fig. 25, represent one-half of the plan of the roof, the width of same being 21 feet. Now draw any line parallel to the eave line of roof, or T U, as shown by V W; take the distance of the

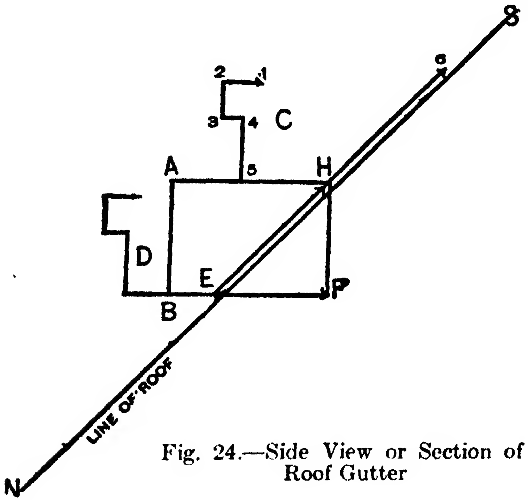


Fig. 24.—Side View or Section of Roof Gutter

projection of the gutter, shown by E F in Fig. 24, and place same at right angles to V W, as shown by V X, Fig. 25. Now draw a line from X to W, as shown. At right angles to the line X W place in the proper position, as shown at A, a duplicate of the profile or section of gutter shown at C or D, Fig. 24. Number the bends of the profile A, Fig. 25, as shown by the small figures 1, 2, 3, 4, 5, H and 6. Now parallel to the line X W draw lines through the numbered bends, cutting the lines R T and S U, as shown. Parallel to the line X W draw a line indefinitely, as shown by X′ W′. At right angles to the line B D in plan draw lines upward from B and D indefinitely, as shown by B C and D E, cutting the line X′ W′ at

the points J and E. Now take the pitch of the gutter, as shown by A B or H F, Fig. 24, and transfer this hight from the point J on the line B C, Fig. 25, as shown by J F, and draw a line from F to E. Then F E will represent the line of the gutter in the true elevation on the point 6 in the profile A in plan view. Now place a duplicate of the profile or section C, Fig. 24, or profile A in plan view, Fig. 25, as shown by A′ in true elevation, the small figures 1′, 2′, 3′, etc., of profile A′, corresponding to the small figures shown in plan view. Through the small figures 1′, 2′, 3′, etc., in profile A′ in true elevation draw lines parallel to the line F E, which intersect with lines of corresponding numbers drawn at right

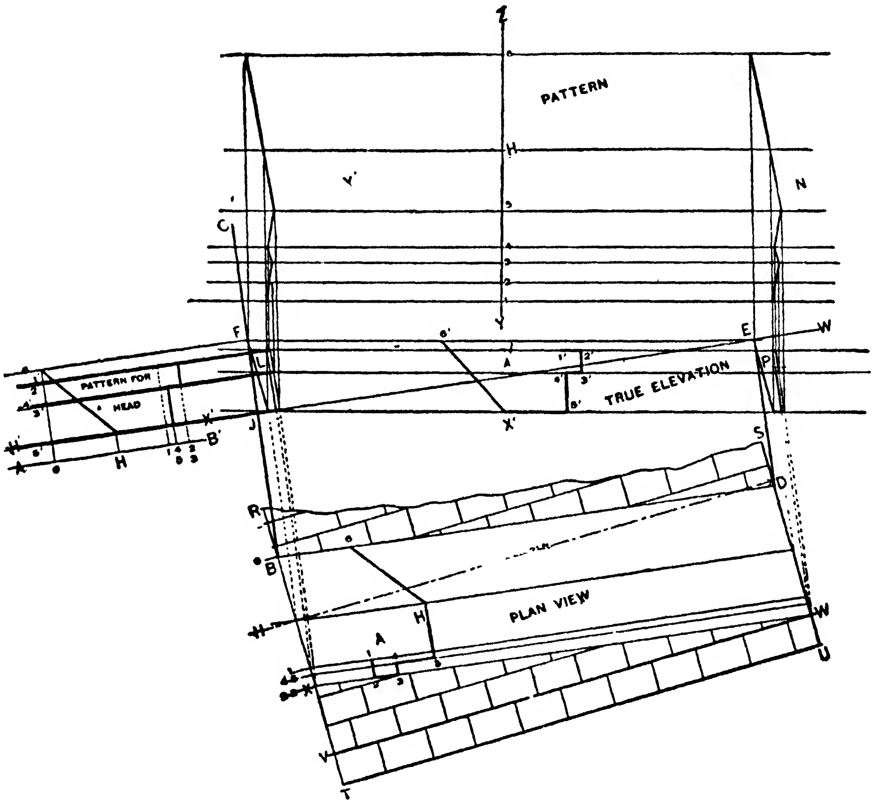


Fig. 25.—Plan View, True Elevation and Pattern of Roof Gutter

angles to the line X W from the intersections made on the lines R T and S U, all as shown. A line traced through these intersections, as shown by L and P, will show the true elevation and miter lines of roof gutter.

To obtain the pattern, proceed as follows: At right angles to the line F E lay off the stretchout of the profile A′, Fig. 25, as shown by the small figures from Y to Z. At right angles to Y Z, or parallel to F E, draw lines indefinitely through

the small figures in the stretchout, as shown, which intersect with lines drawn at right angles to the line F E from the intersections on the miter lines L and P of corresponding numbers. A line traced through the intersections thus made will be the required pattern.

To obtain the pattern for the head of the gutter shown at R and S, Fig. 22, proceed as follows: At right angles to the line B C, Fig. 25, draw lines from the intersections on the miter line L. It will be noticed that these lines are numbered 5′, H′, 3′, 4′, 2′, 1′ and 6′, corresponding to the same numbered lines, drawn through the profile A′, in the true elevation. At right angles to where the gutter intersects the line X B, plan view, Fig. 25, draw short lines, as shown by 2, 3, 4, 5, 1, H and 6, corresponding to the same numbered lines drawn through the profile A in plan view. Now parallel to the lines drawn at right angles to B C draw a line, as shown by A′, B′, upon which place the widths, as shown by 2, 3, 4, 5, 1, H and 6, corresponding to the intersections on the line X B, plan view, as shown by 2, 4, 5, 1, H and 6. Then at right angles to A′ B′ draw lines upward from the small figures, as shown, intersecting lines of corresponding numbers drawn from the miter line L, at right angles to B C. A line traced through these intersections will be the pattern for the head of the gutter required at R and S, Fig. 22.

To avoid any misunderstanding, it is well to remark that the sections shown at C and D, Fig. 24, do not represent the true sections on the lines R T and S U, plan view, Fig. 25, and are only drawn to form basis from which to obtain the measurements of the pitch and projection of the gutter, and are sections of the gutter at right angles to B D, plan view, and sections at right angles to F E, true elevation. The pattern for the head of the gutter, as shown in Fig. 25, is the true section of the gutter on the line R T and S U, in plan view.

In practice it would be impossible to lay out a drawing of 21 feet on the ordinary drawing board, although the gutter could be laid out on the floor. To avoid this and to make use of the drawing board, the entire measurements could be divided into eight parts or less, according to the length of the drawing board in use.

The following explanation is given to illustrate what is meant by dividing the measurements: By dividing the measurements into eight parts, instead of laying off 21 feet, as shown from V to W, Fig. 25, take one-eighth of same, which is 2 feet 7½ inches, and make V W equal to 2 feet 7½ inches; then, instead of making V X, Fig. 25, the projection of gutter, as shown from E to F, Fig. 25, make it one-eighth of E F. And having obtained the line X′ W′ in true elevation, Fig. 25, instead of making J F equal in hight to A B or H F, Fig. 24, make it

one-eighth of the distance. By dividing the length, projection and pitch of the gutter each into the same number of equal parts, the same angles are obtained as in the full size drawing.

It is also proper to remark in this connection that, if but one gutter was being put up, it would hardly pay to get out the patterns as above described, as the time involved in obtaining the patterns would cost almost as much as the amount a small gutter would bring. In such a case the gutter would be made a few inches longer than the desired length and placed on the roof in its proper position, and tacked with a few roofing nails. Then take a carpenter's square and place the long arm on the roof parallel with the eave line, and, holding the short arm of the square perpendicular, mark off a perpendicular line on the top and bottom ends of the gutter where required, and trim with the hand shears or snips. Then the lower cut will represent the miter line on which the second piece of gutter would be joined, and the top cut may be used to obtain the pattern for the flat head, by simply holding a piece of galvanized iron or other metal against same and marking off the shape.

It is, however, a good plan to obtain accurate patterns, as described, which are saved for future use; and when a gutter of this style is required, it can be given the same shape and pitch. Thus the same pattern can be always used, it only being necessary to obtain the amount of pitch required on every gutter of a different length, so that a chalk line indicating the pitch can be struck on the roof on which the bottom line of the gutter is placed.

Now, as above described, if a gutter of 21 feet has 4 inches pitch, then a gutter of 10 feet 6 inches would have but 2 inches pitch, or in other words, the gutter would have a fall of 4-21 inch to the foot. As 4-21 makes the figuring complicated, $\frac{1}{4}$ inch fall to the foot could be given and the patterns cut accordingly. This would make the pitch on 21 feet equal to $5\frac{1}{4}$ inches. In case a gutter was required measuring 21 feet $5\frac{1}{2}$ inches, it would be necessary to obtain the amount of pitch required for the $5\frac{1}{2}$ inches in length. To obtain this without tedious figuring, construct on a piece of heavy white cardboard, for future reference, a triangle whose base is 12 inches in length (divided into half and quarter inches) and the altitude or perpendicular hight as much as the fall of the gutter is to the foot, which in this case is $\frac{1}{4}$ inch. Connect the altitude and the base by a line called the hypotenuse or slant line, which completes the triangle. From the divisions on the base of the triangle draw lines at right angles, intersecting the hypotenuse, or slant line. Then place one leg of the dividers on the $5\frac{1}{2}$ inch division on the

base, and the other leg of the dividers at the point where the 5½ inch perpendicular line intersects the hypotenuse; then the distance between the points of the dividers will be the amount of pitch required for the 5½ inches of gutter. This rule applies to any measurements whatever.

LAYING OUT THE PITCH OF GUTTERS

For example, take a hanging gutter or eave trough, 24 feet 6 inches long, the water to run from left to right standing in front of the gutter and the wire bead to be on the outside, the pitch to be 3½ inches on the length, or, in other words, the pitch to be 3½ inches on A to B, Fig. 26. Two flat heads will be required, which can be pricked from the section shown by C A D for the high-point of the gutter and B A D C for the lowest point, allowing for the wire on C A, for the small head and C B for the large head.

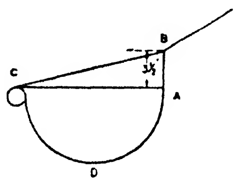


Fig. 26.—Laying Out the Pitch of Gutters

Strike a chalk line on the floor as shown by A B, Fig. 27, assuming that 7 feet sheets are used, then for 24 feet 6 inches, there are required three sheets 7 feet long and one piece 3 feet 9 inches, allowing 3 inches for laps as shown by dotted lines C D and E of Fig. 27. We

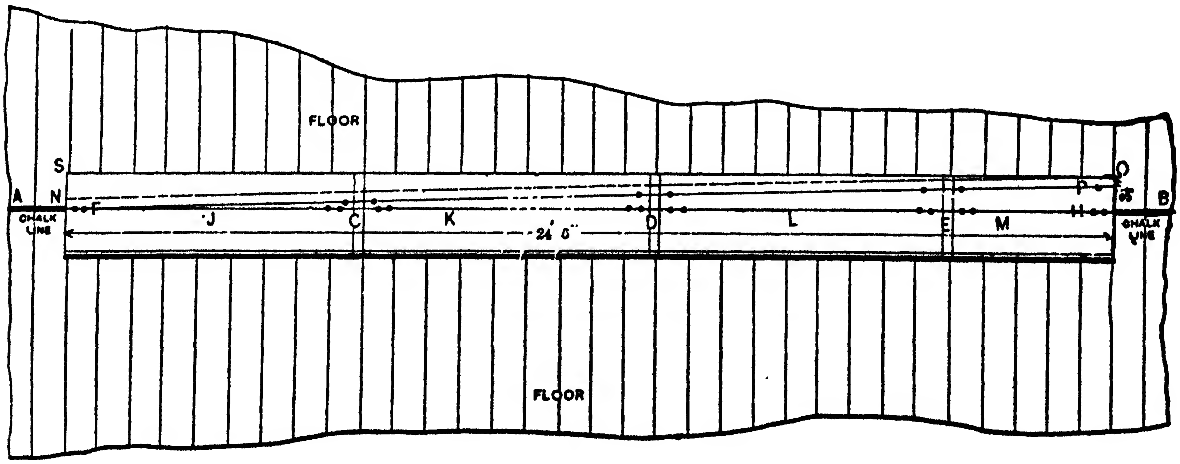


Fig. 27.—Method of Laying Out Gutter on the Floor to Obtain Pitch

now bead the three sheets and the one piece. Next get the stretchout of C D A, Fig. 26, place upon and lay it off across the beaded sheets, marking at each end of the sheet the double dots, as shown on the line F H, Fig. 27. Draw a line through each sheet on the double dots. As the water is to run to the right, we start on the right side with the piece M, placing the line drawn through the double

dots upon the chalk line A B, Fig. 27. Then take the sheet L, and giving 1 inch lap, as shown at E, place the line drawn through the double dots upon the line on the piece M to the right, and on the chalk line to the left, performing the same operation with the sheets K and J. As the double dots shown at F, Fig. 27, represent the high part of gutter, the next step is to measure $3\frac{1}{2}$ inches from the double dots H, Fig. 27, as shown at P. Then strike a chalk line from P to F, as shown, and which will be the line on which to make the bend. If a straight line is desired on roof, strike a line as shown by N O, Fig. 27, parallel to the line P F. The portion at S O to be cut away. In striking the pitch, as shown in Fig. 27, the bead should be laid downward.

MOLDED GUTTER ON BRICK WALL

Fig. 28 shows the method of fastening a sheet metal molding to a brick wall, on which the gutter is formed of wood and then lined with sheet metal. A is a section of the brick wall, the upper portion, L, being built up to but half the thickness of the wall, as shown, thus leaving a space on which to build the gutter, as shown at K. C represents the wooden wall plate, fastened to the wall by means of the bolt B, which has an angle at the bottom. The bolt is placed upon the wall when up as high as shown by the dotted line X. The wall is then built up around the bolt, after which a hole is made in

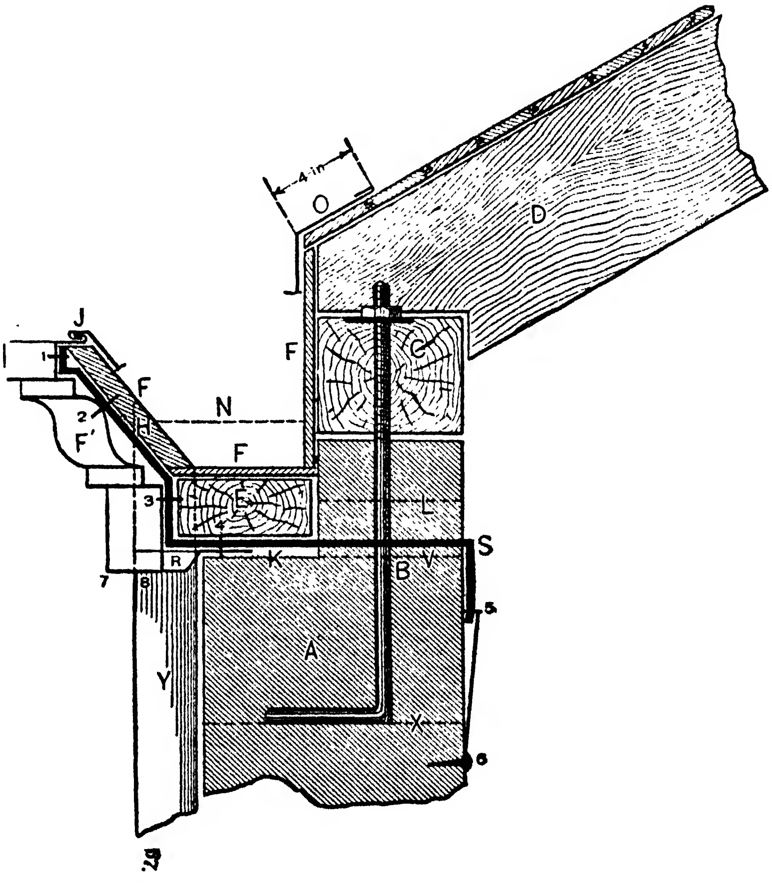


Fig. 28.—Fastening a Sheet Metal Molding to Brick Wall

the wall plate C and set over the bolt and fastened with a washer and nut, as shown. D represents the rafter on which the roof is planked, and to this the flange of the gutter lining is nailed. As all this has no bearing on the cornice work, it is only briefly explained so the reader may better understand the sectional views of this kind of work. In making the details for the molding and brace, shown in Fig. 28, care should be taken that the inside brace, shown from 1 to 5, is so drawn that a portion will meet the top member of molding at 1, at part of the ogee, as shown at 2, at the flat portion, shown at 3, and on the flange of the drip, shown at 4. Bolts are then inserted through the molding and brace, as shown at 1, 2, 3, and 4. The thickness of the wall A is taken and the brace made to extend through it, allowing for a flange to bend down behind the wall, as shown at 5. The length of the flange should be less than the hight of a brick. Care should be taken in drawing the top flange and lock of the molding that the lock J, Fig. 28, comes directly over the center of the gutter plank H, so that when the sheet metal lock of the gutter lining is locked into J of the molding and pounded down with the mallet the blow will come directly over the center of the wooden plank H. If the lock J should come in further than the thickness of the gutter plank H, a bad seam would be the result, because the locks could not be driven together, there being no foundation to pound on. It will be noticed that that portion of brace in Fig. 28 which meets the ogee at 2 at once gives the shape of the gutter on the inside, against which the plank H is laid, as shown.

After the molding is formed on the brake, and set together to the required length, the braces are inserted about 30 to 36 inches from centers, care being taken that the length of the brace from R to S, in Fig. 28, is correct so as to slip over the wall.

The mason, when building up the wall, usually has a scaffold on the front, which is often used by the cornice maker to put up his work. One way to set moldings of this kind is to have the mason stop with his wall when he gets up as far as shown by the dotted line V, Fig. 28. The braces are put in the moldings in the shop, with the flange S 5 already bent. A hole is punched through the brace, as shown at 5, in which to fasten the wire.

Now set the molding and braces upon the wall and have the drip R of the molding fit well against the face of the wall, as shown. As the molding will have a tendency to tip forward when set, fasten a piece of wire in the hole 5 of brace, press down the brace at S firmly onto the wall, and fasten the wire with an anchor nail into the joint of brick work shown at 6. The wall L is now built on top of

the braces, which holds the molding in its proper position. As the full depth of the gutter down to the wall K is not required, blockings of wood are placed upon the braces. as shown at E, Fig. 28. In gutters of this kind the carpenters should prepare the pitch of the gutter. F represents the lowest point of gutter and N the highest; and after obtaining the required length of the gutter the lowest point would be blocked up with wood to the hight of F and the highest point blocked with wood as high as N. A chalk line is then stretched from N to F and intermediate blockings placed. The gutter is planked out as shown by F F F and connected with the roof boards, after which it can be lined with either tin, copper or galvanized iron, locking the lining into the front lock on molding as before explained, and leaving a flange on roof of about 4 inches, as shown at O, which would be sufficient lap whether the roof were covered with tin, slate or shingles.

It is the writer's preference in putting up moldings of this kind to let the mason and framer first finish their work complete. When the work is put up before, by the time the mason has finished his wall and the framer has his wall plate and rafters set the molding is usually pressed out of shape and flattened.

When putting up the molding after the wall is finished, set it temporarily against the wall and mark where the braces will come, so as to cut the holes shown from L to V, Fig. 28. As before explained, the angle of brace S 5 should be less than the hight of a brick, so that the holes cut with the use of a chisel and heavy hammer through the brick wall need be the hight of one brick only. The braces having been slipped through are then drawn down with wire, as before explained, and the mason closes up the holes with brick, thus holding the braces firmly in position. Y in Fig. 28 represents the leader to carry the water from the gutter. The back of the leader, lying against the wall, is carried up through the blockings, as shown by the dotted line, and intersects the gutter on the bottom line F. The front of the leader is run up through the molding and intersects the plank H at F. Now, if the

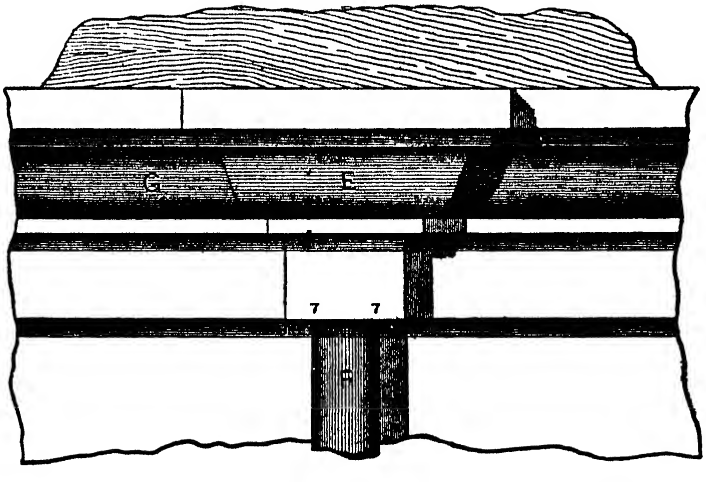


Fig. 29.—Front Elevation of Molding, Leader and Head

leader was left in this position it would deface the entire front of the molding; so to overcome this a projection the width of the leader is placed over it, as shown at F′, Fig. 28. This at once forms a leader or conductor head, the face of which is shown at E, Fig. 29. The projection 7 8 and 7 8, on either side of the leader F, Fig. 29, is the same as the projection 7 8 over the leader Y, Fig. 28.

Fig. 29 also shows a portion of front elevation of the molding G, which miters to the leader head E, as shown.

Fig. 30 is a part of Fig. 28 reversed, showing top brace fastened at top and bottom to prevent the gutter from breaking down when filled with snow and ice.

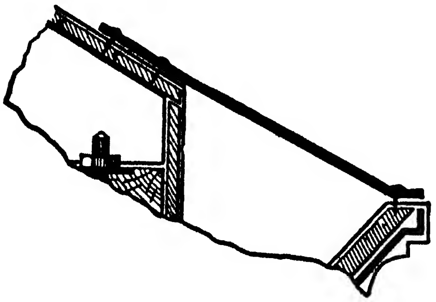


Fig. 30.—Part Section of Gutter, Showing Top Brace

After the gutter is lined and the top lock is soldered watertight a galvanized iron brace is screwed to the roof boards and into the plank to the front of the gutter, as shown. These braces are placed about 30 to 36 inches apart, and are made of 3-16 × 1 inch band iron, the same material being used for the inside braces, shown in Fig. 28.

Having now explained how the work is to be constructed and put up, we are in a better position to take the measurements and obtain the patterns.

Fig. 31 is a rough sketch of the roof plan of a bay window, showing the leader, projection of the leader head and angles of walls. The measurement for the moldings would be taken upon the wall line from A to B, B to C and C to D,

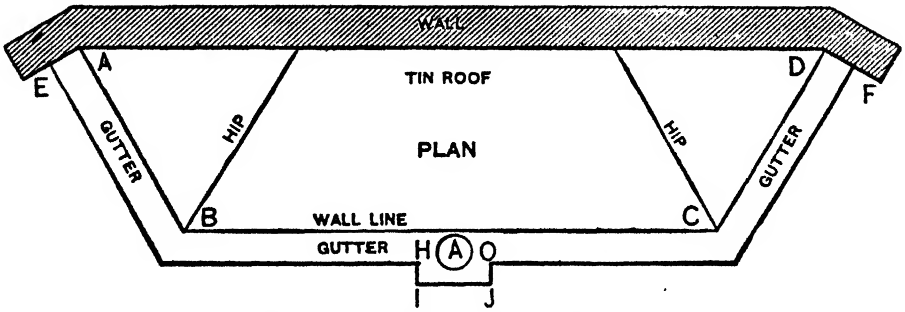


Fig. 31.—Roof Plan of a Bay Window.

the angles A B C and B C D being the same. The angle is taken with a bevel, as explained in a previous article. The angles at A E and D F are square. Two miter patterns would be required, one for the angle A B C or B C D and the other for the leader head shown in Figs. 47 and 48.

To obtain the two patterns for the miters proceed as follows: Let A^2, Fig. 32, represent the section or profile of the gutter, shown at F′, Fig. 28. Place the profile

in its correct position, as indicated, having the line 12 13 of the profile A^2 perpendicular, and divide the profile into a number of parts, as shown. In line with 2 3 of the profile A^2 place the angle of the leader head, as shown by H I J or

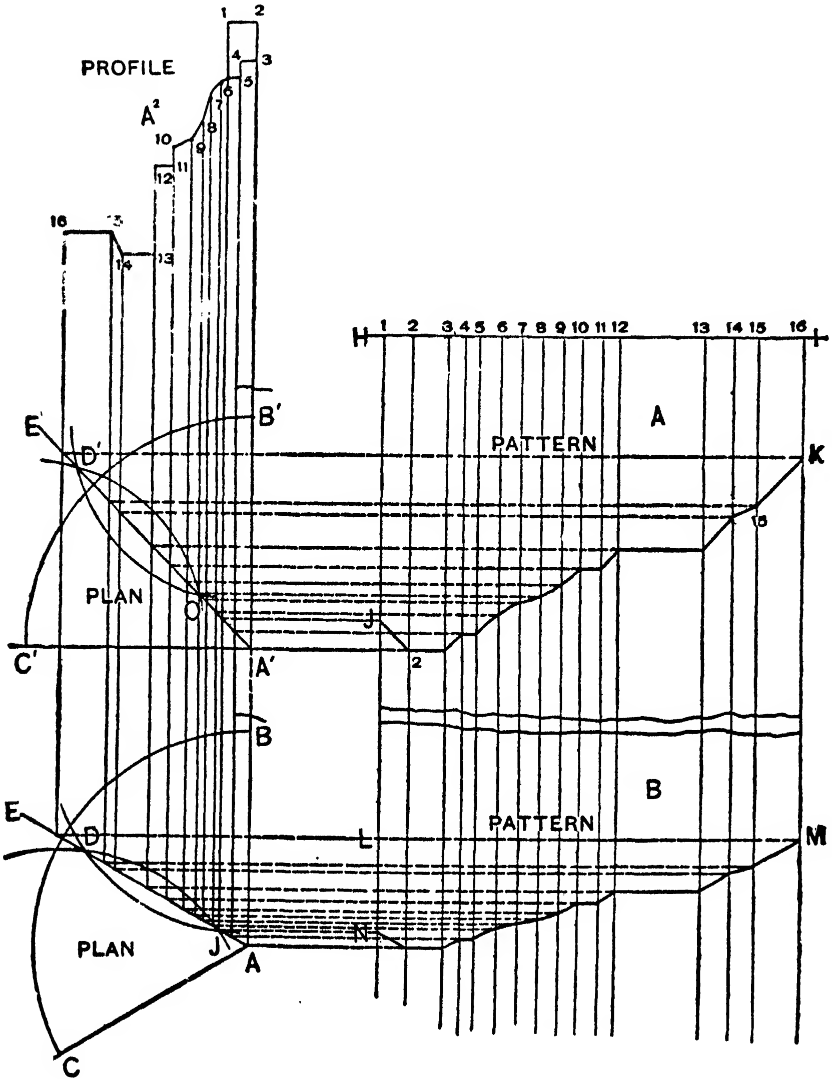


Fig. 32.—Method of Obtaining Two Miter Patterns, Using One Profile

I J O in Fig. 31, which is a right angle, as shown by B′ A′ C′ in Fig. 32. Then again in line with 2 3 of the profile A^2, Fig. 32, place the angle of the wall A B C or B C D of Fig. 31, as shown by B A C in Fig. 32.

The next step is to obtain the miter lines of these two angles, for which proceed as follows: Place one leg of the compass at the point A′, Fig. 32, and strike an arc, as shown, from C′ to B′. Now, with C′ and B′ as centers strike the two

arcs, as shown intersecting each other at D′ and O. A line drawn through these two intersections will be the required miter line, as shown from E′ to A′.

The same method is employed for obtaining the miter line for the other angle. With A as center strike the arc from C to B; then with C and B as centers strike the two arcs shown intersecting each other at D and J. A line drawn through D and J will be the required miter line, as shown from E to A, Fig. 32. When miters for different angles are required, and the profile is the same, it is well to use this method of placing the miter lines under one another, thereby saving considerable time in spacing the profile for each miter line.

From the divisions on the profile A^2 drop perpendicular lines, as shown, cutting the miter lines E′ A′ and E A. At right angles to the perpendicular lines draw the line H I indefinitely, upon which place the stretchout of the profile A^2, as shown by the small figures 1, 2, 3, 4, etc. At right angles to the stretchout line H I draw lines indefinitely from the small figures, which intersect with lines of corresponding numbers drawn from the intersections on the miter lines E′ A′ and E A parallel to the line H I. Draw lines through these intersections; then H I K J will be the miter pattern for the angle required for the leader head shown at E, Fig. 29; and L M N the miter pattern for the angle taken on the wall line A B C or B C D, Fig. 31. It will be noticed that the angle B′ A′ C′, Fig. 32, is a right angle, and that the pattern obtained is for a square return miter. The method here shown is the long rule for obtaining square miter patterns, and it is the writer's preference always to use the short method; but when cases arise where miter patterns are required at other than right angles, and a plan must be drawn as B A C in Fig. 32, then we can just as well draw the plan of the right angle B′ A′ C′, as but one operation is required to intersect any number of miter lines.

Fig. 33 shows the method of cutting the full size patterns from a sheet of iron with as little waste as possible. Let A B C D represent a sheet of iron, upon which the patterns for the leader head are to be laid out.

In practice, the front edge of the sheet at B would be cut straight, so that the lock would show an even edge when bent at the brake, and to which the lock of the gutter lining would be attached, as at J, Fig. 28. A stretchout of the profile A^2, Fig. 32, is now taken upon a strip of zinc about $\frac{3}{4}$ inch wide, upon which the bends of the moldings are dotted off. These dots are now transferred upon the sheet by placing the zinc stretchout even on the line A D, Fig. 33, and dotting off the sheet by means of a scribe awl and hammer. Horizontal lines are then drawn through these dots, which represent the bends of the molding. Next turn the

pattern A of Fig. 32, and place the line 2 2 of pattern to correspond with the line 2 2 upon the sheet of iron in Fig. 33, and mark the miter, as shown, from H to I, with a scribe awl. Take the width of the leader Y, Fig. 28, and place it as shown

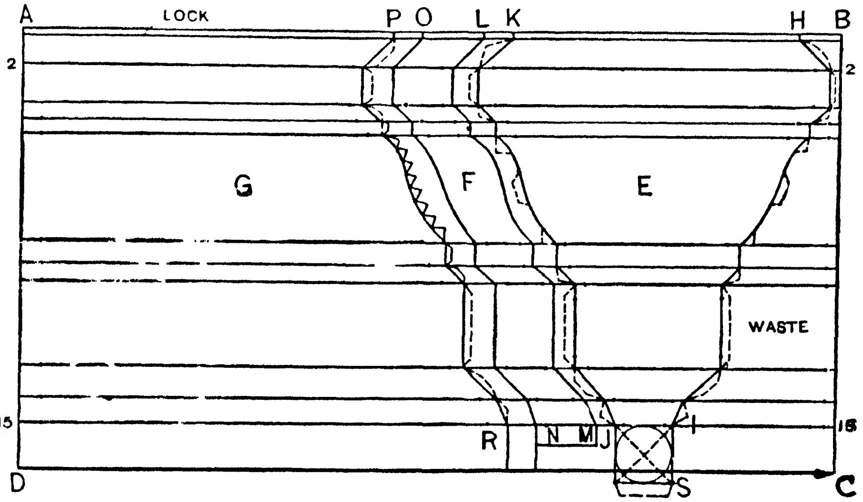


Fig. 33.—Method of Cutting Full Size Pattern

from I to J on the line 15 15, Fig. 33; then, reversing the pattern A of Fig. 32, lay the point 15 of the miter upon the point J on the line 15 15, Fig. 33, and having the line 2 2 of the pattern upon the line 2 2 of the sheet of iron, mark the miter, as shown, from K to J. Then will K H I J or E of Fig. 33 represent the pattern of the face of the leader head shown at E, Fig. 29. As the bottom of the leader head is to be placed on the face E, Fig. 33, and the sheet of iron not being wide enough, a small piece of iron would be soldered on. At right angles to I J draw I S, equal in length to I J, and make a square, as shown. Draw the dotted diagonal lines, the intersection giving the center point from which to strike the circle corresponding to the diameter of the leader Y, Fig. 28, and which would be cut out with a circular shears or snips. This completes the pattern for the entire face and bottom of the leader head, laps being allowed, as shown by the dotted lines.

Where the leader head intersects the moldings, as at H and O, Fig. 31, it is called an inside miter. Therefore the pattern A of Fig. 32 would be placed in such a position on the sheet of iron shown in Fig. 33 that L M would represent a reverse cut, or inside miter. As M N of Fig. 33 would be joined to I S, take the width of I S and place it as shown by M N and L O, and mark the miter cut. Then will L M N O or F of Fig. 33 represent the projection of the leader head, shown at F′, Fig. 28, and the miter cut O N of Fig. 33 be connected to the face E on the cuts J K of H I. Now take the pattern A of Fig. 32, and place 2 2 of the pattern

upon the line 2 2 of the sheet of iron and mark a reverse or inside miter, as shown by P R, Fig. 33. Allow laps, as shown by the dotted lines from P to R; then will A P R D or G represent a portion of the molding G, Fig. 29, on which the leader head would be joined, the cut L M on Fig. 33 being joined to P R of the same illustration. The measurement on the molding would be made upon the line R 15 of Fig. 33, that being the bend which sets upon the brick wall. Whatever more molding would be required to obtain the desired length would be joined to the piece, G, Fig. 33, having the miter cut the same as B, Fig. 32, for the angles A B C or B C D, Fig. 31.

ANOTHER MOLDED GUTTER ON BRICK WALL

Fig. 34 is another form of molded gutter for brick wall, showing the method of fastening it to the wooden wall plate B. A represents the brick wall, B the wall

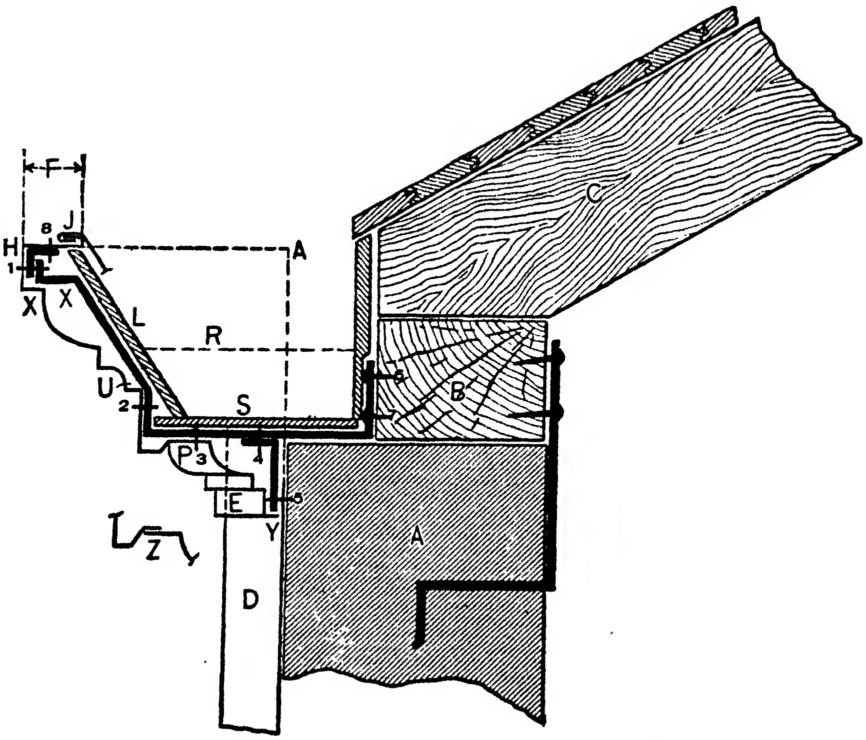


Fig. 34.—Fastening Sheet Metal Molding Against Wooden Plate

plate, and C the rafter upon which the roof boards are fastened. It will be noticed that part of the molding, from P to E, drops down over the wall, and that the top bend of the molding has an angle iron inserted at H.

After the detail of the molding is made, draw a section of the angle iron in the top edge, as at H, also marking the position of the bolts through angle iron, shown at 1 and 8. Now draw the top flange and lock of the molding, making the top flange as wide as shown at F, so that the bolt 8 passing through the angle iron will have plenty of play room to pass the lock J; or, in other words, the lock J should be placed at such a distance from the bolt 8 that the gutter lining can be locked into the lock J, without interfering with the bolt. When making the detail of the inside brace, care should be taken that it meets the angle iron at 1, and the length of the brace at X X should be such that when the plank L is laid upon the portion of the brace from X to U it will come directly under the lock J; in this way, when the gutter lining is locked into the molding the seam can be pounded down tight. The other portion of the brace should meet the molding, as shown at 2 and 3, then back to the wall plate with an angle bent upward and nailed to the wooden plate at 6 and 7. The small angle at 4 and 5 is intended to keep the drip molding tight against the wall, without nailing or defacing the molding. The angle should be fastened to the main brace by means of a bolt, 4, and then bolted through the flange of galvanized iron at 5. The hole 5 should be countersunk, so that a smooth surface is obtained. Care should be taken in bolting the angle 4 5 to the main brace that one is exactly like the other, otherwise the drip molding will not lie even against the wall. The length of the stove bolt which is inserted into the hole 5 should not be greater than the inside width of the member Y of the drip molding.

After the molding is formed and set together to the required length the angle iron is held in position with hand vises, as explained in a previous article, until the top bolts are all inserted from the bottom up, as shown at 2, Fig. 35. After the top bolts are all in place and the nuts fastened the front bolt 1 is placed through the molding, angle iron and brace and fastened on the inside; the bolts are also inserted at 2 and 3, Fig. 34, and the angle bolted to the main brace at 4, being careful to have the distance from the angle 4 5 to the angle 6 7 the same as the distance from the front of the wall to the wall plate B. The angle irons and braces can all be put in the molding in the shop. Let us suppose the molding is 28 feet in length, in which there are ten braces. In hoisting up on the wall two ropes would be required, looping and fastening each rope on each side to the third brace from the end and tying around the brace X, Fig. 34. When the molding is up set it on the wall, and drive two anchor nails into the wall plate B at 6 and 7, thus drawing the drip Y tight against the wall. The gutter is now lined with wood by

the carpenter, S being the lowest point and R the highest point, it being blocked up with wood, as explained in a previous article. The gutter is then lined with either tin, copper or galvanized iron and locked into the lock of the molding at J, Fig. 34. In Fig. 35 is shown a part of Fig. 34 reversed, with the top brace bolted to the angle iron and screwed to the roof board. At 1 is shown the bolt, passing from the outside through the molding, angle iron and brace and fastened on the inside. In putting on the top brace, shown in Fig. 35, care must be taken when loosening the nut of the bolt 2 that the bolt does not fall inside of the molding. To prevent this lay a strip of wood onto the part of brace X X, Fig. 34, before the gutter is planked, to uphold the bolt 8 when the nut is loosened.

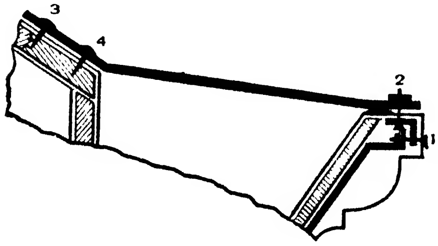


Fig. 35.—Part of Gutter with Top Brace

After the top brace is bolted at 2, Fig. 35, screw to the roof planks, as shown by 3 and 4. This top brace will keep the gutter from bending down from the weight of the snow and ice. In milder climates, where the snow is not considered, the top braces could be omitted.

Let D, Fig. 34, represent a square leader, meeting the lowest point of the gutter S, as shown by the dotted lines. To make a neat finish where the leader

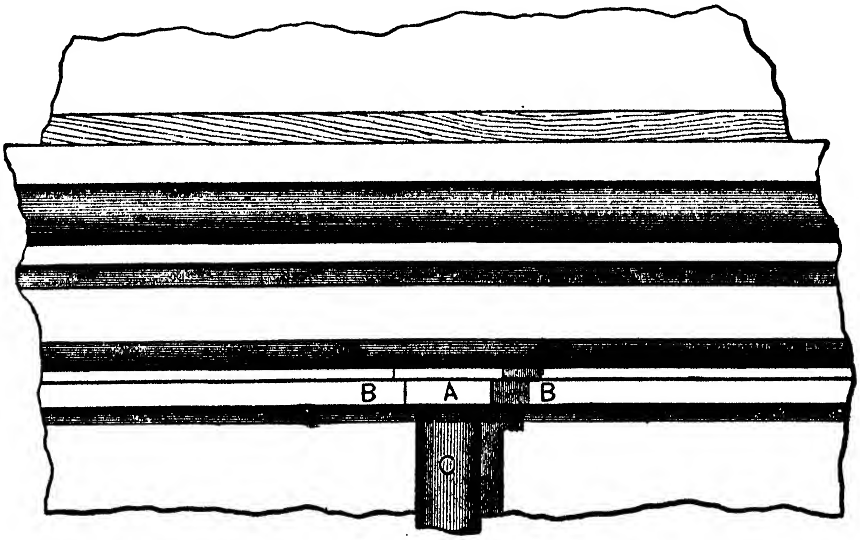


Fig. 36.—Front Elevation of Molding, Leader and Head

D cuts through the drip molding, a small head is made for the leader, having the same projection as the leader D, as shown by P E. Fig. 36 is a portion of the

front view of molding, leader and leader head, the section of which is shown in Fig. 34. B B represents part of the drip molding, A the leader head and C the leader.

Having now explained the method of construction, as shown by the front and sectional views, we will proceed to take the measurements and obtain the patterns.

Let A B C D, Fig. 37, represent the plan view of a tin roof, showing the brick walls and the molding on the front from A to B. O represents the section of a square leader, shown in Fig. 34 at D, and in Fig. 36 at C. When measuring the length of the molding, measure upon the wall line from 1 to 2, Fig. 37. As no

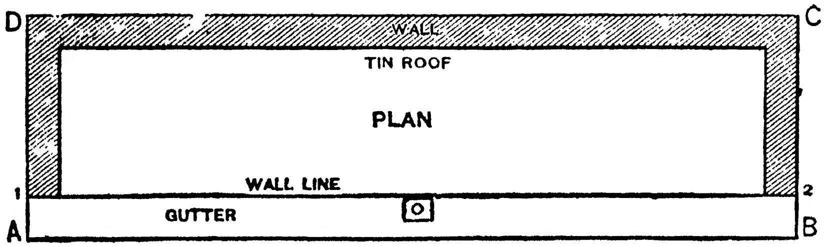


Fig. 37.—Roof Plan, Showing Leader and Gutter

return miters are required in the molding, two flat heads, shown at A and B, Fig. 37, are placed on each end of the molding. As the water is to run to the center of the building, the leader will be placed at O, Fig. 37, with a projecting leader head to the hight of the drip molding, the face of which is shown in Fig. 36 at A, and the projection in Fig. 34 at P and E.

To obtain the patterns for the flat heads for the moldings, proceed as follows: In line with the wall shown in Fig. 34, draw a dotted line as shown from 5 to A′, and at right angles to it draw a dotted line, H A′, meeting the top bend of the molding H.

Transfer this angle, including the profile of the molding shown in Fig. 34, upon a piece of galvanized iron, by placing the galvanized iron underneath the detail of the molding and pricking through by means of a scribe awl and hammer. The result is shown in Fig. 38 by A B C. In pricking through the profile on detail, it is best first to divide the profile into a number of parts, so as to obtain the stretch-out, and then prick through these divisions.

As the molding usually is made to represent stone after being painted and sanded, and as stone work always shows the bearing upon the wall from the side view, it is well to add 4 inches or more to the pattern of the flat head, as shown from D to E, in Fig. 38.

Now take the stretchout of the top flange of the molding, shown from H to J in Fig. 34, and transfer it as shown by F and G, Fig. 38, at right angles to A D, and add the lock, as shown from H to I.

At right angles to D A, Fig. 38, draw the line A J. Take the distance of the flange D F in Fig. 38 in the dividers, and placing one leg on the point J strike an

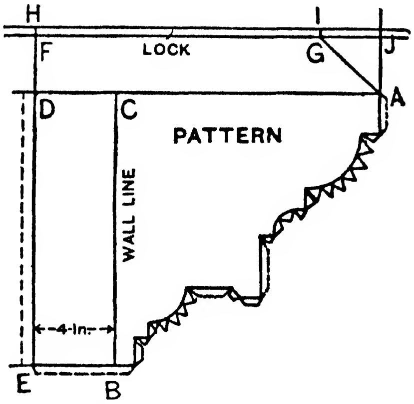


Fig. 38.—Pattern for a Flat Head

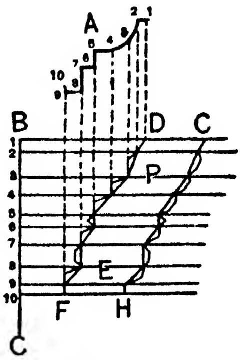


Fig. 39.—Pattern for Return on Leader Head

arc intersecting the line F G at G. Draw a line from A to G, which will be the miter for the top flange of the head, mitering with the top flange of the molding at right angles in plan, shown by 1 A B or A B 2 in Fig. 37. At right angles to F G, Fig. 38, draw G I, which completes the patterns. Allow lugs, as shown.

For the pattern of the leader head proceed as follows: Draw a duplicate of the profile of the drip molding, shown in Fig. 34, at A, Fig. 39. Divide A into a number of parts, as shown. Now draw any perpendicular line, as B C, upon which place the stretchout of the profile A at right angles to the line B C, and from the small figures draw lines indefinitely, as shown. From the divisions obtained in the profile A drop perpendicular lines intersecting the corresponding numbers drawn at right angles to the stretchout B C. A line traced through these intersections from D to F will be the required miter pattern. Now take the distance of the projection of the leader, shown at D, Fig. 34, and with the dividers measure the distance from the miter cut D F, Fig. 39, on the lines 1, 2, 3, 4, etc.; trace a line through the points, as shown, from C to H. Then D F H C, or P and E, will be the pattern required for the projection of the leader head shown by P E, Fig. 34.

In Fig. 40, B A and B represent a sheet of iron, on which part of the bends of the molding have been lined, as shown. Let us suppose that, the length of the molding having been obtained, the leader will come in the position on the sheet shown by J K. Now use the pattern P E, Fig. 39, and place the point F, Fig. 39,

upon the point K, Fig. 40, placing the line F H of Fig. 39 upon the line K H of Fig. 40, and draw the miter line shown from M to K. Now have J K, Fig. 40, the

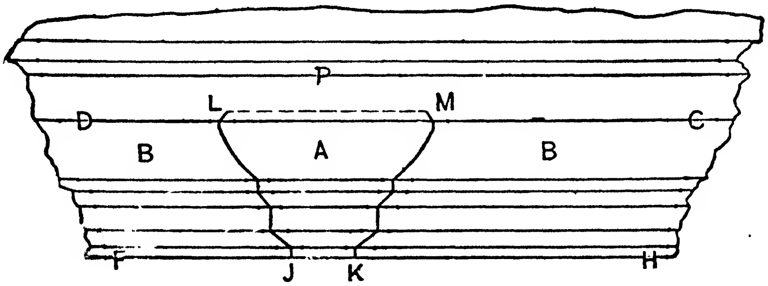


Fig. 40.—Laying off the Miter on the Sheet

width of the face of the leader shown at C, Fig. 36. Reverse the pattern P E of Fig. 39, and place the point F upon the point J, Fig. 40, placing the line F H upon the line J F, and mark the miter line shown from L to J. As the projection of the leader head comes out as far as up to the line P, Fig. 40, when the molding is formed, we can add a small lap, as shown from L to M, to the pattern A of Fig. 40. Now, taking the right handed snips, cut out the pattern, A of Fig. 40, commencing at the point K, on the miter line up to M, over to L and down to J.

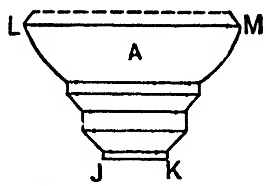


Fig. 41.—Pattern for Face of Leader Head

A in Fig. 41 represents the pattern for the face of the leader head which was so obtained. It will be noticed that the face A of Figs. 40 and 41 has no lap attached, the same being the case with B and B of Fig. 40. For this reason laps have been added to the pattern for the return on leader head, shown at P and E in Fig. 39. The miter cut C H, Fig. 39, is joined to the cuts M K or L J, Fig. 41, and the cut D F, Fig. 39, to the cuts M K or L J, on the sheet B B, Fig. 40, when setting together.

TEN FORMS OF GUTTER CONSTRUCTION

In the following article are shown 10 different forms of gutter construction used under different conditions. The simple forms are those used on frame structures, while the complicated are employed on fireproof construction. In Fig. 42 is shown the simple form used under the eaves of shingle roofs. A is a double beaded gutter fastened to the roof C by means of the hanger B. These hangers can be obtained in wire or strap form or of malleable iron from dealers in tinners' supplies. In Fig. 43 A shows a regular half-round eave gutter, turning on the

roof at B. When the roof is tile, slate or shingles, the flange B is made 8 inches wide. When the roof is of metal a lock is attached to this flange B as shown at C.

In Fig. 44, is shown another style of gutter, the bottom of which rests on the brick wall and the back of which is flanged to the roof boards with a lock at *b* for

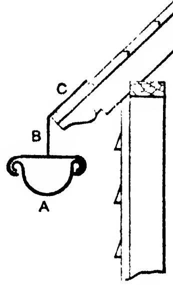


Fig. 42

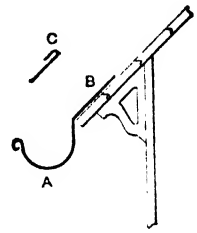


Fig. 43

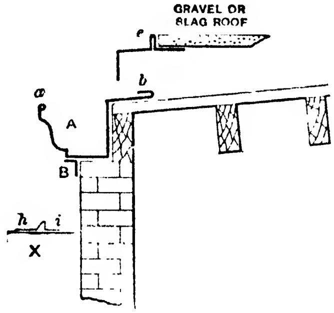


Fig. 44

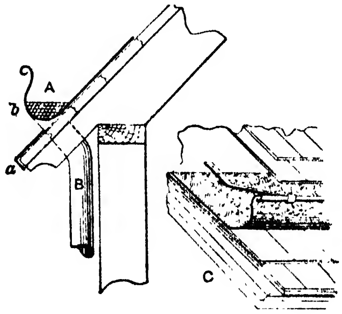


Fig. 45

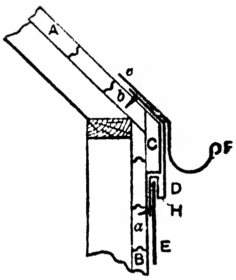


Fig. 46

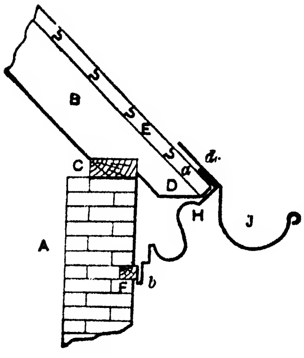


Fig. 47

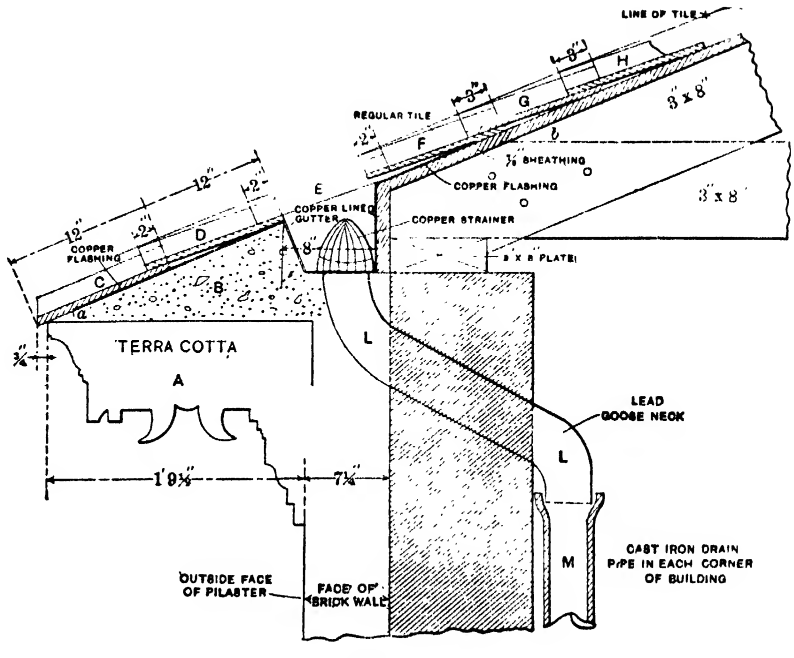


Fig. 48

Different Forms of Gutter Construction

locking purposes. When the roof is of gravel or slag a guard is placed on the gutter flange, bending it direct to the gutter as shown at *e*, or making a V-shaped guard and tacking it with solder to the gutter flange, as indicated at X by *h* and *i*. This

guard prevents the tar or slag from running into the gutter in hot weather. A wire edge *a* is placed at the top of the gutter, and to this the ordinary braces are fastened. In case the gutter overflows the water has a tendency to follow the face of the mold and run between the gutter and brick wall, thereby causing a leak. This is overcome by soldering an angle B along the entire length of the gutter before it is set; this acts as a drip and leads the overflow over the face of the wall.

In some cases where an eave gutter is objectionable a roof gutter is employed, as shown by A in Fig. 45. If the roof is covered with tin the lower part at the eave *a* is first covered a short distance under the gutter as shown, after which the gutter is set, allowing a lock along a level line to which to lock the flat or standing seam roofing. Should the roof be covered with shingles, slate or tile, the lower part of the eave is first covered, as shown in diagram C; then the gutter is set with the required pitch, the braces fastened and the rest of the roof laid as indicated. Leader connections are usually made as indicated at B with wire mesh bent V shape to act as a strainer over the outlet, as shown at *b*.

When the front or face of a building is covered with corrugated, V-shaped, pressed brick or any other style of metal covering, or when faced with shingle or slate, the rafters running flush with the building line, the finish at the eave is made as follows: After the roof boards A and face sheathing B in Fig. 46 are in position, the required blocking C is nailed in position, and the metal casing D is nailed over the wood blocking at *a* and *b*. A groove is formed as shown, and into this is placed the face covering E, the drip H protecting against leakage in case of an overflow. After the casing D is in a position the gutter F is set in the usual manner, allowing a lock at C if necessary for metal roofing.

Fig. 47 shows another style of construction when the rafter B projects over the brick wall. The rafters are generally set upon the plate C and cut at an angle shown by D at the bottom. The sheathing E is then placed, being careful to have a furring strip or blocking built in with the wall to the required hight, on which to nail the eave mold. This strip is shown by F. Having obtained the proper projection and hight, the molding is nailed to the roof at *a* and to the bottom of the blocking at *b*. Better practice is to use wood screws to fasten at *b*; this prevents the loosening of the lower part of the mold by the nails being drawn out through the action of the weather and sun. When the mold is up the gutter J is set, fastening at *d*, or using band iron hangers and top braces.

Fig. 48 shows a case of fireproof construction when the gutter is hidden below the roof line. The roof is covered with tile in this instance, but the method of

construction is similar, no matter what the roof covering may be. A shows the terra cotta cornice supported on the wall. The roof rafter rests on the 3 × 8 in. plate, the roof and back of the gutter being sheathed as shown. The top of the cornice is filled with concrete, as shown by B, to continue in line with the sheathed roof as shown. In this concrete the gutter is formed, and the gutter is lined with cold rolled copper down to the eave as far as *a* and on the sheathed roof as far as *b*. In laying this gutter all seams should be first tinned, then locked and sweated with solder, being careful to fasten it with cleats.

The gutter being lined, the tile roof is started by using closed end tile, then the regular tile, allowing 2-inch lap. The gutter is so placed so that the third tile will lap over the top of the gutter, as shown by C, D and E. This third tile E is only placed at the ends of the roof to make a finish when viewed from below, and is omitted otherwise so as to allow the rain water to drain into the gutter. The remainder of the tile are laid in regular order, as shown by F, G and H. The gutter is drained to the inside of the building in each corner, or in recesses built in the wall, to cast iron pipes, as shown by M. At L L is shown a sheet lead goose neck which is run from the gutter J and caulked into the iron pipe M. A copper basket strainer J prevents the outlet from being choked with dirt, leaves, etc.

When a gutter is to be joined to a stone cornice, coping or the like, the work is accomplished as shown in Fig. 49, in which A is the stone or terra cotta cornice and B the roof rafter. At its proper place a groove or raglet is cut into the stone shown by A, or if terra cotta this raglet is molded into the clay before hardening. The wood blocking C and the lining of the gutter F is first completed by the carpenter, after which the molding D is set in position with a lock at E and an edge into the raglet A. On a good job this raglet is filled with molten lead or plugged with lead at intervals and then filled with molten sulphur. Sulphur makes a tight job and need not be caulked like lead, because when the sulphur cools it expands, while the lead contracts on cooling. The molding D being fastened, the gutter lining is now placed in the position shown, locking at E and allowing a lock at G. The lowest point of the gutter is at F and the highest point at H. The leader connection is similar to that shown in Fig. 48.

In Fig. 49 the forward part of the stone or terra cotta cornice is left exposed to the weather, which in some cases is objectionable and is overcome as shown in Fig. 50, in which holes A are drilled into the stone or modeled into the terra cotta about 18 inches apart, 1 inch in diameter and about 1½ inches deep. These holes are plugged with lead, and when the blocking B is completed the molding D is

set, with a beaded edge at *a*, which acts as a drip. Brass screws are put through the metal D and screwed into the lead plugs A. The screws should not be soldered to the metal, but a concave cap should be set over them and soldered. This makes a tight seam and allows for the expansion and contraction of the metal, as shown at X. The gutter lining is locked into C and the leader connection made in the usual manner.

Fig. 51 shows a rigid form of gutter construction on which the painters' scaffold can be hung if need be. Using this construction there need be no fear

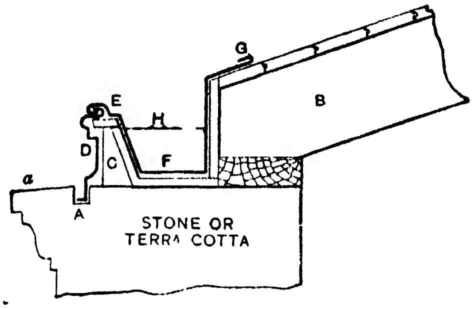


Fig. 49.—Gutter in Stone or Terra Cotta Cornice

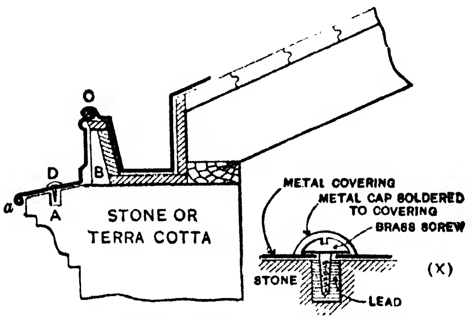


Fig. 50.—Gutter in Stone or Terra Cotta Cornice.

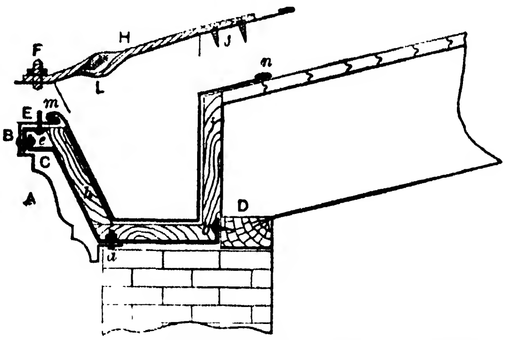


Fig. 51.—A Rigid Form of Gutter Construction

of expansion when the gutter freezes in the winter. It is a construction used on all first-class jobs. After the wall has been built to its proper hight and rafter D put in position the distance is measured from the front edge of the wall *a* to the front of the plate *b* and the necessary brace made. The angle iron B is $1\frac{1}{4} \times 1\frac{1}{4}$x $\frac{1}{4}$ inches in size and runs throughout the entire front edge of the cornice. It is bolted to the brace C at *e* and through the top of the cornice at E. A bolt passes through the brace and cornice at the drip *a*.

The cornice A is now set upon the wall and fastened to the wooden plate D at *b*. This draws in the drip snug against the wall. The gutter is then planked as shown by *h j*, it being noted that the lock *m* is so placed that the plank *h* meets

it to allow the closing of the lock *m* with the mallet when the gutter lining *m n* is locked to it. After the gutter is lined and the lock *m* soldered, top galvanized iron band braces are bolted across the top of the gutter as shown by H. E represents the bolt ready to receive the top brace, which is indicated at F, which shows the nut. The brace is then screwed to the roof as at J. When using band iron braces the tendency of the water when flowing down the roof is to follow the brace and allow small streams of water to flow over the front. This is overcome by putting the twist in the brace as at L. The water is then directed into the gutter and the construction incidently makes the brace more rigid. The bolts for the top braces are placed about 2 inches beside the inner brace C and a metal wedge or strip placed under the head of the top bolt to keep it from falling on the inside after the gutter is lined.

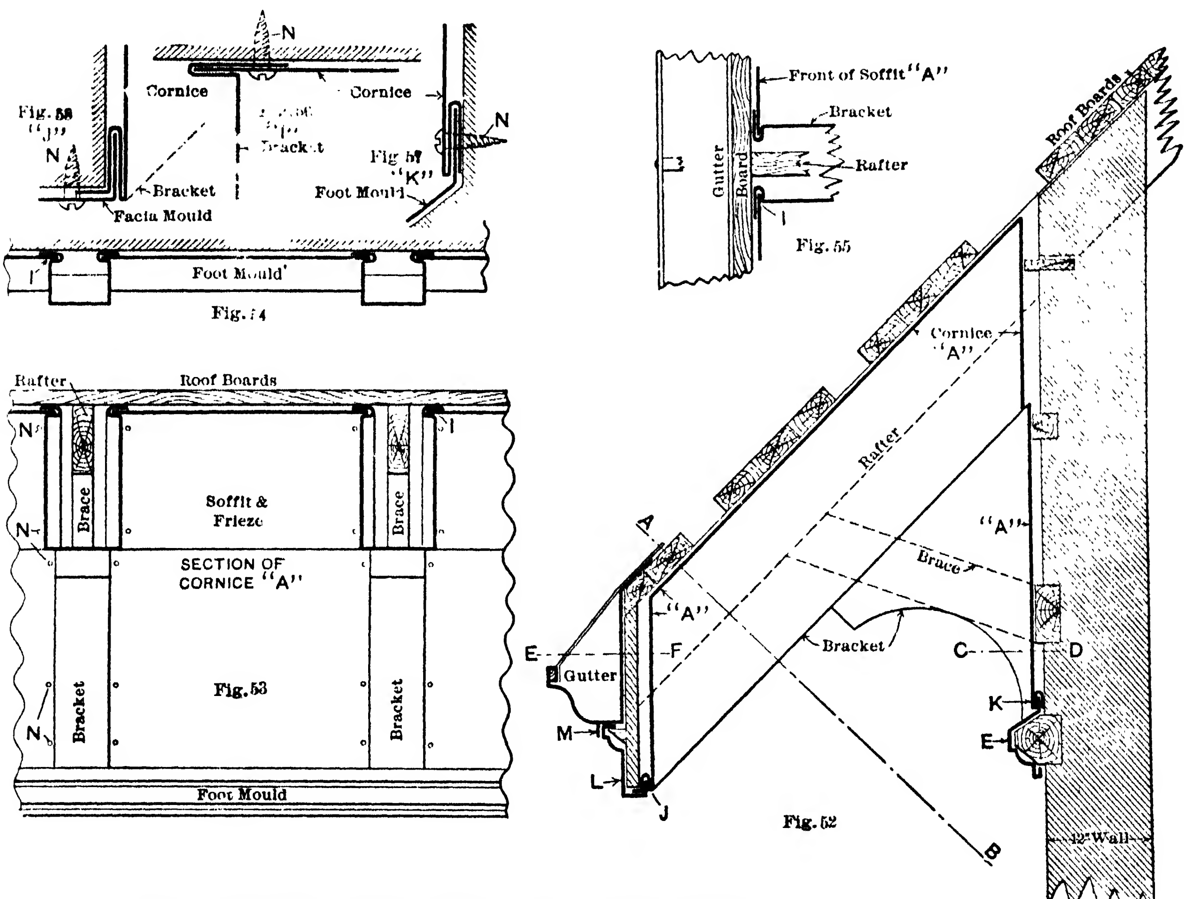
PRACTICAL TALKS ON GUTTERS—I

A cornice recently used on a building provides the subjects for the accompanying illustrations. The design was intended to enhance the effect of the overhung roof, which was supported by braced rafters 3 feet 6 inches apart, a large bracket covering each rafter and its brace; the space between brackets being filled in with a cornice of plain, unmolded metal.

Fig. 52 is a vertical section through the wall and overhung roof, showing sections of the cornice and gutter, a side view of the brackets and a dotted line view of the wood rafters and brace. Fig. 53 is a section on A B; Fig. 54, a section on C D; Fig. 55, a section on E F; Fig. 56, an enlarged view of the adjustable slip lock connection between brackets and cornice; Fig. 57, an enlarged view of lock K, and Fig. 58, an enlarged view of lock J.

It will be seen from the illustrations that the rafters and braces cut the cornice almost completely in two and practically resolve it into a series of short filling-in pieces between the brackets. This suggested the idea of making an adjustable interlocking connection between the brackets and cornice sections. Therefore, the brackets were made with reverse, bent inwardly, projecting grooves or locks on the front, top and back edges, into which the raw edges of the soffit and frieze section of the cornice could be inserted and secured. Section A was formed with lock K to connect with the foot mold E, and lock J to connect with the fascia mold L. The foot mold E and fascia mold L were made in 20-foot sections. The work was then delivered to the building and put up as follows:

A 20-foot section of foot mold E was first secured in place by screws, and then the first bracket—which, of course, was suitably modified to form an end bracket—was secured in place by nails driven through the groove lock flanges into the wood backing. A section of A was then placed in position by raising it into place alongside of the bracket, springing the vertical back of the same to a curve, so that



Practical Talks About Gutter Work.—Eave and Gutter Finish

lock K could be raised and slipped over the upwardly projecting flange of foot mold E, and then sliding A along against the bracket and into the grooves or locks on the edges of the same, securing by screws, N, which passed through A and the bracket flange and into the wood backing. The next bracket was then placed in position, slide locked to section A and secured thereto and to the wood backing by screws N. Thus a section of A and a bracket were alternately secured in position until the first 20-foot section of foot mold E was covered. Then a 20-foot section of

fascia mold L was put in place and secured by screws to the wood backing. The bottom edge of the brackets at the point J having the same groove lock as section A at that point, a continuous groove was thus formed to receive the upwardly turned inner edge of fascia mold L. A section of gutter provided with a lead drip M, was then placed in position and secured by ordinary braces, thus completing one section of the cornice. Several roof boards were temporarily left off in order to allow access to the back of the cornice, which made it easy to connect the slide lock joints.

It will be seen that, owing to the adjustability of the slide locks, the work was assembled in place on the building, with the brackets properly spaced, even quicker than it could have been put together in the shop, with the advantage, in the former case, that the work was completed, whereas, in the latter case, it would not only still have been necessary to erect the work after assembling it, but it would have been difficult to get all the brackets spaced to exactly suit the spacing of the rafters.

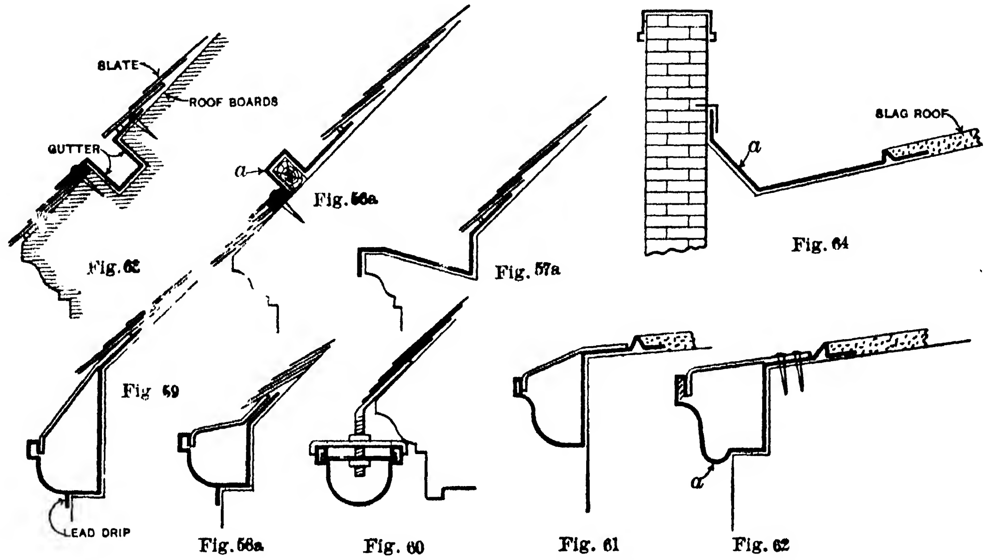
The principle underlying the construction used in this case, *i. e.*, the use of adjustable lock connections between the brackets and cornice sections, where the cornice is nearly severed by its supporting brackets, could be more largely used than it is. Modifications to suit the conditions in each case will, of course, be necessary; but the principle is good and can be safely recommended.

PRACTICAL TALKS ON GUTTERS—II

Gutters constitute one of the most important branches of the tin and cornice business. They are made in various forms, typical illustrations of which are shown herewith. The form of a gutter changes with the climate in which the building is located, conditions being created in Northern latitudes by low temperatures that never, or, at least, seldom, occur in Southern latitudes. Thus roof drainage is a much simpler problem in warm climates than in cold.

In designing gutters for use in warm climates, there are but three general conditions to meet, viz. That the gutter be large enough, that it be pitched to the outlets and that it be made water tight. Any of the forms shown can be made to meet these requirements, of course; but, in gutters for use in cold climates, the additional requirements occasioned by contraction and the presence of ice and snow must be met. For instance, in draining an ordinary slate roof in New England, it is advisable to use a gutter which, when filled with ice, will not act as

a dam to the water which falls upon or is melted from the ice on the roof, thereby forming a pool which will back up over the slates behind the gutter and flow into the building. Gutters like those shown in Figs. 56a, 57a, and 58a will cause this



General Remarks About Gutters

result, whereas gutters like those shown in Figs. 59, 60, 61, and 62, being placed at the extreme edge and which do not project above the plane of the roof, will not constitute such an obstruction.

Usually gutters are set when the weather is comparatively warm, and, in cold climates, provision should be made for the contraction of the metal, which occurs later. This contraction should be provided for by expansion joints, placed not more than 50 feet apart. The necessity for these joints is another reason why a form of wall gutter should be used, as the joints are most readily made in this form of gutter. The usual manner of constructing these expansion joints will be shown in a later article. The object of the joints is, of course, to afford a flexible point or connection to take up the expansion and contraction in the length of the gutter, thus releasing the seams of strain, and consequently lessening the liability of leaks from broken seams.

In copper gutters, the end lap seams should be tinned before the gutter is formed, and when joining the 8-foot sections together in the shop, after forming, the joints should be riveted, the rivets being placed not more than 2½ inches apart, and the seams then soaked full of good solder, using a clean flux and a large, well heated soldering copper. In joining the 16-foot or 24-foot sections on the building, the joints should be riveted as much as possible and then heavily soldered.

All wall gutters should be stiffened with galvanized or tinned iron bars, not smaller than $1 \times \frac{1}{4}$ inch, and twisted dogs, $1 \times \frac{1}{8}$ inch, and 30 inches apart, well riveted to the bar and secured to the roof. Such gutters should also be provided with drips, either formed integral with the gutter, as in Fig. 62, or a lead drip securely soldered thereto, as in Fig. 59. The latter method is preferable, for the reason that the bottom of the gutter is left plain and free from bends, and the dip or groove *a*, Fig. 62, incident to the former method, thus being less likely to catch and hold leaves and debris that tend to corrode the metal. Furthermore, the pendant lead drip can be bent or dressed to suit irregularities in masonry work, which cannot be done when the drip is formed integral with the gutter.

Ice is not likely to form and remain in gutters of the types shown by Figs. 63 and 64, for the reason that the entire under surface of the gutter is within the building and therefore exposed to the heat from below, which prevents the adhesion of ice to the gutter, leaving a free passage for the water to the outlets at all times.

PRACTICAL TALKS ON GUTTERS—III

Different methods of getting out and laying or putting up some of the gutters shown in the preceding article are described as follows:

First, take Fig. 63, already mentioned. Assuming the material to be tin or copper, it should be first put together in rolls of proper width, and the seams well locked and soldered, care being taken, if the gutter is of copper, to tin as much of the ends of the sheets as will be taken up by the locks before turning the edges. The carpenter or mason usually leaves a stage in position at the eaves, and as the roof below the gutter should be slated before the gutter is put in, thus necessitating the presence of the slater with his roof stages, the next step is to take the gutter in rolls to the building and form it on the spot, as follows:

Roll the material out on the roof just above and parallel with the gutter, securing it in a perfectly straight line with small nails in the extreme top edge, but partly driven, using the stages above mentioned to operate from. Then take a narrow strip of metal the length of which equals the width of the gutter lining, and form it to the profile of the gutter trough at one end of the same, by pressing it into place in the trough; prick punch the bends. Remove and straighten the strip, lay it on the corresponding end of the gutter lining, and transfer the prick marks from the strip to the lining. Repeat this operation at the other end of

the stretch. The length of the stretch is governed by the distance between the highest and lowest points in that slope or portion of the gutter. Now, mark the two middle bends by chalk line the full length of the stretch, and make the lower middle bend with the gutter tongs. Tack a few blocks on the roof below the gutter and adjacent to the face just turned up, to prevent the work from sliding down the roof. Then remove the retaining nails in the upper edge, and turn the upper middle bend with the tongs, thus resolving the work into a long U-shaped trough, except that the bottom is flat instead of rounded. Now drop the lining into place in the gutter and hold down with the foot, pressing on a narrow board laid in the bottom of the gutter, and bend the top and bottom laps or aprons over on the roof above and slated roof below, respectively.

Just before turning the apron over on to the slate below the gutter, a brake or angle of about 45 degrees should be turned on the edge of the same with ½-inch gauge roofing tongs, thus insuring that the edge of the metal will lie close to the slate. This apron should be secured by screws passing through the slate, or, what is better, a narrow board about the thickness of the slate roofing should be laid on the roof flush with the lower edge of the gutter trough, against the lower edge of which the slate ends, thus forming a protection for the slate, as well as means of securing the metal apron. The upper apron is simply nailed along its edges to the roof boards, and finally covered by the slates or shingles.

Another method is to form all the bends in the brake in 8 or 10 foot lengths, and deliver the work to the building in sections. This is a much quicker method, provided the carpenter work of the gutter is straight and accurate, but such a carpenter job on gutter troughs is seldom met with.

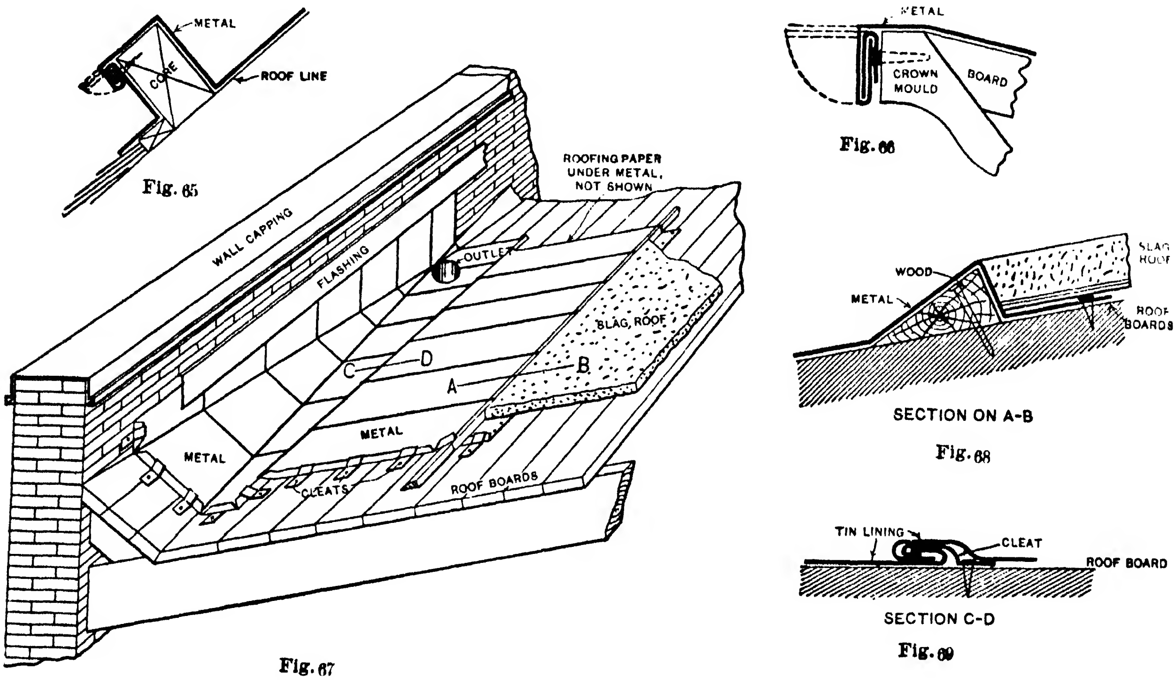
The advantages of the first method are, rounded bends that do not crack or strain the metal, close fitting of the lining to the wood work, saving of seams and saving of time in measuring and making dimension sketches. Its only disadvantage is the comparative difficulty of bending, which is not serious. The one advantage of the latter method is the comparative saving of time in forming, its disadvantages being sharp bends, except when certain brakes or dies are used, discrepancy between the profile of the lining and that of the trough, thus leaving the lining improperly supported, multiplicity of seams to make outside of the shop, and time consumed in measuring dimensions and making sketches.

A gutter like that shown in Fig. 56 is very easily made and applied, and can be satisfactorily formed on a brake, as the hight of the wood core above the roof is the same at all points, the pitch of the gutter being obtained by placing the core

at a slight angle with the eave. When the metal is not wide enough to form the entire stretchout in one piece, a lock seam is usually made at "a," Fig. 56a, as indicated in Fig. 65.

What has been said about the gutter, Fig. 63, applies to the gutter, Fig. 57a, but, as the latter must be neatly finished over the outer edge of the crown mold, something will be said on that point.

A method of finishing a gutter edge is shown in Fig. 66, which has been found effective and economical. Strips of galvanized iron are cut and bent at right



Construction of Gutters

angles in the brake or bar folder, to form angle pieces 5-8 inch on one side and $\frac{1}{8}$ inch less than the width of the face of the crown mold on the other. The narrow leg of the angle is then nailed to the face of the crown mold with the wide leg flush with its top, the gutter lining is then hooked over the wide outstanding edge. All is bent down together as far as possible with a pair of roof tongs, and then laid up close to the face of the mold with a block and mallet, thus no nails or raw edges are left exposed.

In a gutter, as shown in Fig. 64, the pitch is usually obtained by running the bottom line of the gutter at an angle with the wall, which varies the width of member "a." Therefore, the best way to manage this gutter is to turn the locks on the flat sheets, first tinning the edges, if copper is used, and then take the

material to the building and lay it directly in place, as shown in Fig. 67, using cleats, not under edge nails. Heavy roofing felt should be used under the metal.

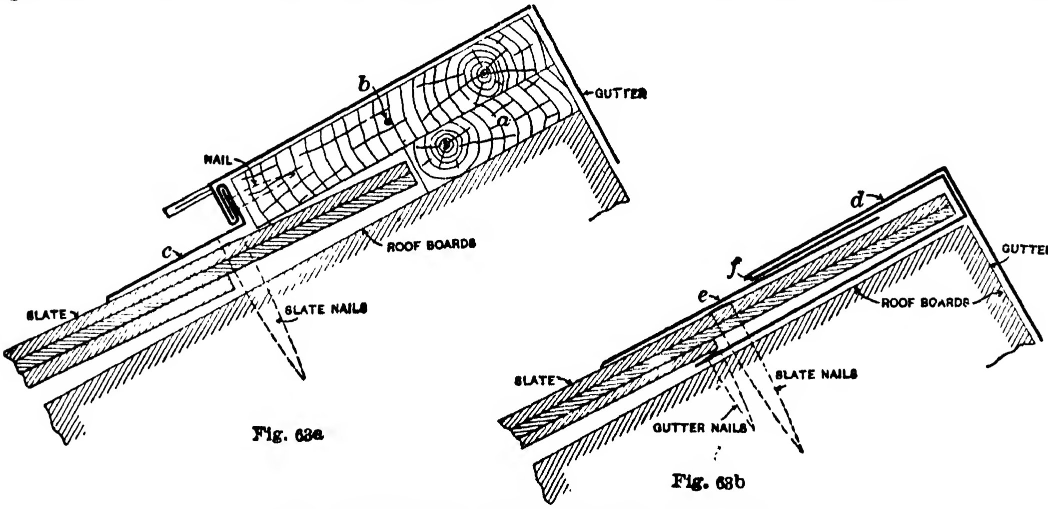
In some cases, where the girth admits, the gravel edge can be made in the shop on the brake, and used without support; but, as a rule, it is better to nail a ¾-inch wood ground strip on the roof and form the metal over it, thus having the otherwise unsupported gravel member protected against crushing if stepped on.

Fig. 68 is an enlarged sectional view on line A B of Fig. 67 and Fig. 69 a similar view on line, C D.

Thoroughly solder the seams and cap flash the edge against the wall with heavy sheet lead, extending at least 2 inches into the wall in moderate climates and 4 inches in cold climates. It is always best to build in the flashing as the wall is laid.

All tin or galvanized iron gutter linings should be thoroughly painted on the under side long enough before laying to allow the paint to dry.

Attention has been called to the likelihood of the nails in the lower edge of the gutter, shown in Fig. 63, being drawn out by the sun. Other methods of



Improved Methods of Slate and Lining Connection

finishing this lower edge are, therefore, shown in Figs. 63a and 63b, which obviate the difficulty mentioned. The entire gutter is not shown, it being deemed sufficient to show the edge to be finished. Referring to Fig. 63a, it will be seen that a wood strip, *a*, is nailed on the roof flush with the lower edge of the wood gutter, against which the slate finishes. The thickness of this strip should equal the thickness of the slate roof. On top of strip *a* another strip, *b*, about twice as wide as strip *a*, is nailed. Strip *b* extends down over the slate about 2 inches. To the lower edge of strip *b* a metal strip, *c*, is nailed, as shown, the top edge of which is turned down parallel with the upper surface of strip *b*. The gutter is locked on to this edge, as indi-

cated by the dotted lines, and then double seamed down over and forming a covering for the nails which secure the metal strip *c*, and at the same time securing the lower edge of the gutter, by means of the seam, in a neat and substantial manner.

In executing this finish the first thing to be done is to nail the strip *a* in position; then finish up the slate roof, after which wood strip *b* is nailed in place, the metal strip *c* applied, and the gutter double seamed thereto. It will be noted that metal strip *c* covers the nails which secure the upper course of slate.

Another method of finishing the lower edge of roof gutters, shown in Fig. 63b, is by means of a slate pocket. It will be seen that the pocket, *d*, is formed on the lower edge of the gutter into which the slate finishes. A separate strip, *e*, is then inserted into this pocket for the purpose of covering the slate nails. Strip *e* is secured in place by soldering to the gutter at intervals at the point *f*. As there is no strain on this strip, securing by solder is a durable method.

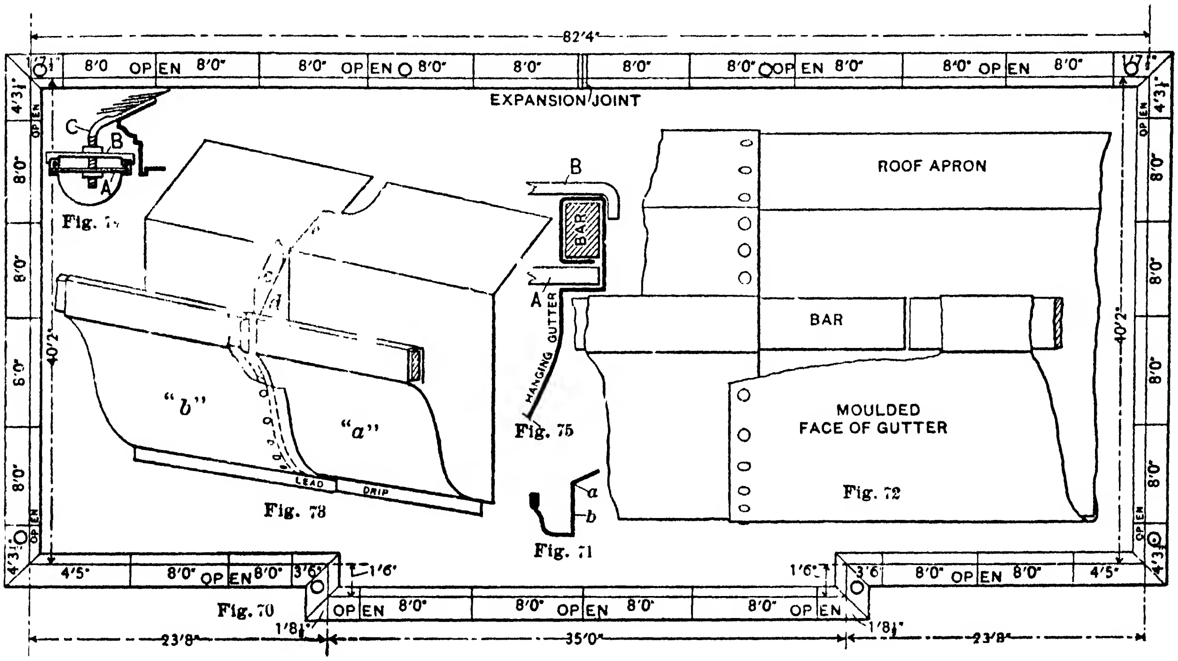
Either of these methods can be applied to gutters as illustrated in Figs. 56a and 63 respectively, or to any form of roof gutter the lower edge of which finishes over a slate, shingle or tile roof.

PRACTICAL TALKS ON GUTTER WORK—IV

In getting out and putting up copper wall gutters like those shown in Figs. 60, 61 and 62, the following methods have been found to be good: Assuming that patterns and measurements have been provided, the next step is to lay out a dimension sketch or plan of the gutter, as in Fig. 70, indicating and marking the length of each sheet or section, as shown. Then cut and mark the stock according to the sketch, being careful to do all marking on the inside surface of the gutter so that the brake man will know how to form the pieces, right or left. Also mark the surface of each lap to be tinned. It is only necessary to tin contact surfaces. Now, tin the laps, and form the gutter, except the bend *a*, Fig. 71, which should generally be made when the gutter is set in place on the wall, as it is difficult to make this bend in the shop, so that the member *b* will vary in the exact proportion necessary to suit the pitch of the gutter.

In the meantime the gutter bars and dogs should be prepared. The bars should be cut a trifle shorter than the length of the gutter sections, measured on the outer edge of course, and punched for the dog rivets. The dogs should be cut, punched and twisted, and the end which rivets to the bar bent, leaving the roof bend to be made outside with a properly constructed pair of bending wrenches.

Now put the gutter together in 16-foot sections, or as shown on dimension sketch, Fig. 70, "open" indicating the seams to be made at the building, and put in the bars, being careful to allow the bars to project several inches out of one end



Construction of Hanging Gutters

of the gutter section, leaving it that much short at the other end, so that when the sections are joined on the building, the joints of the gutter and bar respectively will be dodged or broken, as indicated in Fig. 72, which avoids weakening the gutter at the joints.

Before the bar is put into the gutter it should be laid on the outer face of the same, and the dog rivets holes marked on the copper, so that after the bar is folded in place there will be no difficulty in locating and punching the holes through the copper.

As the dimension sketch, Fig. 70, shows a straight stretch of gutter over 80 feet long, it is necessary to use an expansion joint constructed as follows: Referring to Fig. 73, it will be seen that the two adjacent sections of gutter each have end heads, *c* and *d* respectively—that is, section *a*, being placed at the extreme end of the section and the top edge cut off on a line drawn from the inner top edge of the gutter bar to the roof bend, while the end head *c* in section *b* is placed about 1½ inches back from the end of the gutter section and projects up about 1½ inches above the end head in section *a*, as indicated. When the gutter is put up sections

a and *b* are laid together end to end, as shown, with a space of about $\frac{1}{8}$ inch between the respective end heads, the lap *c* is bent down over *d*, and the roof apron seam, *e*, well soldered.

In putting up gutters of this kind the use of nails driven through the bottom or back of the gutter for the purpose of holding it down to its seat should be avoided, as the dogs are amply sufficient for this purpose when properly formed and secured. The dogs should be riveted to the bar with large copper rivets and secured to the roof with large tinned wrought iron nails well soldered and wiped around. In soldering or wiping around the dog nails a gasoline torch should be used to heat the dog nails and surrounding copper so as to insure the thorough soaking of the solder under and between the entire contact surface of the dog and copper, thus removing the possibility of the entrance of water through the holes pierced in the copper by the dog nails.

In making the "open" seams the torch should be used to warm the bar member and enable the solder to flow completely around the bar,so that the seams will be watertight up to the top edge of the bar. It is difficult to accomplish this or successfully solder the dogs if the heat of a soldering copper alone is depended upon.

The gutter seats on walls are usually pitched to the outlets, but in putting up "flat back" hanging gutters it is left to the metal man to look out for the pitch, there being no wall seat, therefore it is advisable for him to use a spirit level in setting such gutters, as the builders cannot be depended upon to leave the roof eave exactly horizontal. In the rare cases where the eave is left exactly level the roof bend of flat back gutters can be made in the shop with safety, it only being necessary to lay the loose pieces end to end in a straight line, forming stretches of gutter on the floor, locate the roof bend at each end, allowing for pitch, connect with a chalk line and bend the several component pieces in the brake at the chalk mark. It would be a simple matter to figure the location of the roof bends in all gutters if the masonry or carpenter work was accurate, but such is seldom the case.

Ordinary eave trough hanging gutters, which together with the hangers can be bought from stock, is too well known to justify description, but a special hanging gutter now being largely used by New England's leading architects will be briefly described.

A general view of this gutter is shown in Fig. 74, and an enlarged section through one end in Fig. 75. It will be seen that the bars are not punched, there being a horizontal longitudinal recess left under same which receives the end of

the supporting dog. A and B is the clamping dog. The threaded roof dog C passes through both the clamping and supporting dogs and is provided with a nut below the latter and another nut above the former. It will be seen that the threaded and nutted roof dog not only carries the gutter but provides for the pitch; the supporting dogs A connect the gutter with the roof dogs C, and also prevent the sides from moving inwardly; the clamping dogs B prevent the sides from spreading, and being about $\frac{3}{4}$ inch distant from the supporting dog, forms together with same a support or fulcrum that braces the gutter against tilting or twisting when stepped on or struck by ice on its outer edge. The roof dogs are countersunk into the roof boards and secured by two large screws, and the gutter are usually constructed easily carries the weight of a man.

HINTS ON MAKING CONDUCTOR PIPE AND EAVE TROUGH

These are the methods adopted by a successful sheet metal worker and are presented here for a guide to others when equipping a sheet metal working shop for making articles so that they will be regular in size and thus avoid annoyance. In my shop a varied line of sheet metal work is done, yet I have a great deal of demand for eaves trough and conductor pipe; as I am frequently called upon to repair, renew and extend some of my work, it is important that the size shall be regular to avoid trouble and expense.

In making these articles I use an 8-foot cornice brake, a groover and edger and a crimping machine. Conductor pipe is made in 30-inch lengths, with a grooved seam that is flattened down tight with a mallet and tacked with solder in the center. At the squaring shears, I have a gauge for every size of conductor pipe—2, 3, 4, 5 and 6-inch—so that every piece of pipe that is cut is exactly the same in size and we never have trouble in getting them to fit.

We cut all the tubes connected with eave trough $\frac{3}{8}$ inches smaller than the conductor pipe. This saves a lot of trouble, and it is surprising to see how easy it is to connect a conductor pipe when it will slip up readily over the gutter tube or outlet.

For eaves trough I use what is commonly known as the ogee gutter in every possible place where I can, as it is easy to form, easy to rivet together in lengths, easy to solder, easy to paint, and, what is most important, it always looks well and pleases almost everybody.

As will be seen from the illustration, a sharp, square bend is avoided in order to prevent breaking the galvanizing. At the top the front is bent as shown to form a finish, and a double edge is provided to give strength. At intervals varying with the size of the gutter, braces are riveted to strengthen the gutter as shown in the sketch.

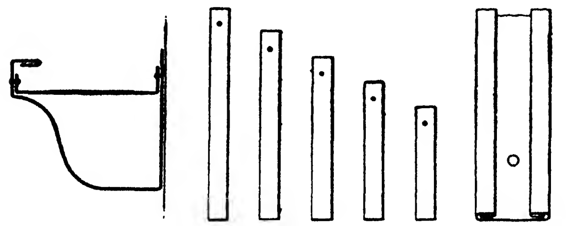


Fig. 76.—Section of Eaves Trough and Conductor Gauges

My down-spout or conductor-pipe gauges are made of galvanized iron 2 inches wide and have a double edge. They have a hole punched in one end so they can be hung up, and the size is marked on them with a prick punch so there can be no mistake.

EAVES TROUGH FOR 30-FOOT RADIUS

It is probable that if the eave trough is erected in relatively short sections that even from a close distance it will have the appearance of conforming to the circular line of the building without itself being curved. Assuming that it may not be convenient to obtain eave trough in lengths as little as 4 feet, 8 foot lengths could be cut in two. Then the effect of using straight sections 4 feet long can be brought out by reference to Fig. 77. This shows a portion of a plan of the roof in which the distance from A to B, or radius of the curve, is 30 feet. The drawing is not to scale, but will serve to indicate the idea and on that account does not need to be drawn strictly to scale.

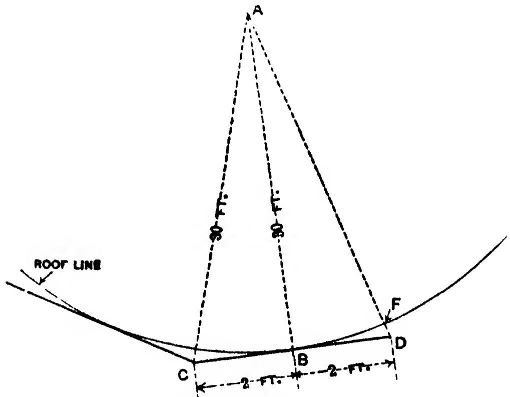


Fig. 77.—Eaves Trough for Roof 60 Ft. in Diameter

Suppose that a section of the eaves trough is laid with its middle point perpendicular to the end of the radius at the point B, so that its end C extends 2 feet one way from the radius A B and the other end D also 2 feet. If we connect the points A and D this line will cut a circle of the outline of the barn roof at some point as F. Obviously, the distance A F must be 30 feet, so the interesting thing is to determine the length of the line F D, or how far from the curve of the barn roof the end of the 4 foot length of eaves trough will lie. The line A D is the hypotenuse of a right angle triangle of which the sides are 30 and 2

feet long. Its length is, therefore, equal to the square root of the sum of the squares of the lengths of the two sides, or the square root of the sum of 900 and 4, or 30.60. This indicates that the length of the line F D is 0.06 ft., or about ¾ in. Whether it would be advisable or possible to spring the eaves trough a matter of ¾ in. in a length of 2 ft. may be a question, but it would seem that if eaves trough of about this length were erected so that one section slipped into the end of the other with a slight angle, the eaves trough could be built to conform as closely as needed to the outline of the roof. It is possible that it would be advisable to put up the 4 ft. lengths so that the center in each case lies slightly within the circle of the roof edge bringing the ends of each section slightly beyond the circle.

GUTTER AROUND A CIRCULAR CORNER

Flaring strips must first be cut for the various sections of the gutter; then raised and stretched to the desired profile and curve of the veranda, as follows: First, draw the profile of the gutter, as shown by A B C D E in Fig. 78, and 3 feet from the eave line D draw the vertical line *c a*. Divide the profile of the gutter into as many spaces as the gutter is to have sections, which in this case are four, as shown by A B, B C, C D and D E. Then through A B average a line, as shown, intersecting the vertical line *c a* at *a*. In a similar manner average lines through B C, C D and D E, intersecting *c a* at *b*, *c* and *d*, respectively. With *a* as a center strike the blank or pattern J, obtaining the stretchout from A B, and adding for the wire, as shown. In a similar manner obtain the blanks H, G and F, using *b c* and *d* as centers. Edges are allowed to the patterns, as shown. After being raised and stretched the pieces are joined by riveting and soldering, as shown in diagram X, where the wire is shown by A^1 and the various positions of the laps by B^1, C^1 and D^1. The blanks J and H are raised in pieces about 30, or 36 inches long as shown in Fig. 79, where A is a wood or lead raising

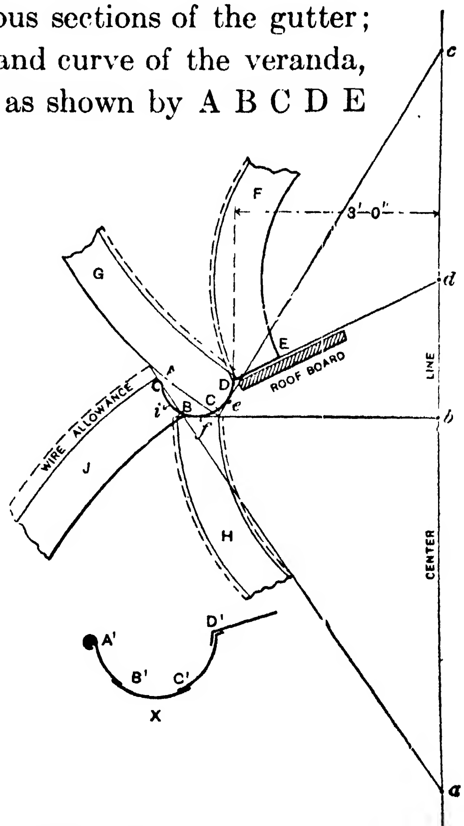


Fig. 78.—Gutter Around a Circular Corner. Obtaining the Blanks

block, B the proper sized raising hammer, and J or H the blank. The center of the blank is first hammered; then the buckles are drawn out along the edges. While A B and B C, in Fig. 78, are raised on the block, C D must be stretched, as shown in Fig. 80, in which A is the mandrel or blowhorn stake, B the stretching

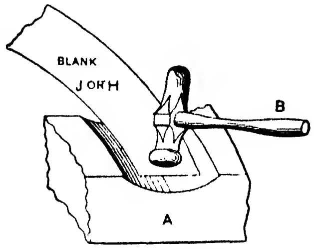


Fig. 79.—Raising Blanks J and H

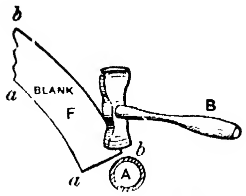


Fig. 80.—Stretching Blank F

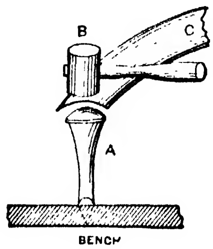


Fig. 81.—Dressing the Molds

hammer and F the blank, which is stretched along the edges *b b* and *a a* . When the blanks have all been formed to their required shape they are dressed upon the round head stake, as shown in Fig. 81, by placing the mold C upon the stake A and using the mallet B to take out any buckles. Some little skill is required upon the part of the mechanic to bring each mold to its proper shape.

BEADING GUTTER WITH HAND TOOLS

In the accompanying illustrations are shown the four operations employed for beading gutters by hand.

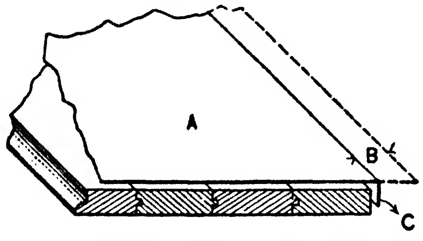


Fig. 82.—Beading Gutters. Bending the Sheet

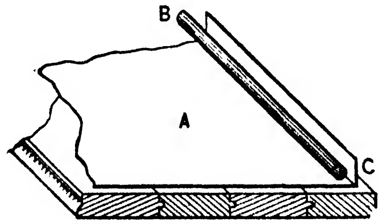


Fig. 83.—The Position on the Bench

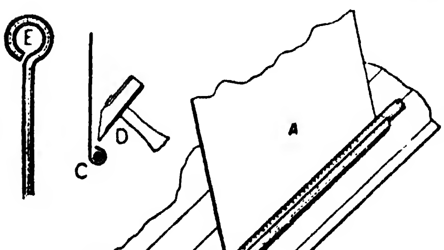


Fig. 84.—Bending the Sheet

In Fig. 82, A shows the sheet of metal on the bench projecting over the edge of the bench as far as B (the amount of material required to incase the bead). It is then turned down with the mallet, as indicated at C. This first operation could be avoided by making a bend in the brake as shown at C. The second operation is indicated in Fig. 83, where the sheet A is laid upon the bench with the edge C turning upward. Now

take the required size rod or gas pipe, place it as shown at B, and using the mallet turn the metal C over the rod, when it will look as shown at A in Fig. 84. Then, holding the sheet in the position there shown, turn the metal tightly around the rod B, as shown in diagram C, using the sharp edge of the hammer D, being careful not to make any dents on the sheet A. When this operation is completed the rod is tightly incased.

To remove the rod so that the other sheets can be beaded, lay the sheet A flat upon the bench and tap lightly along the bead with the mallet, when the rod can easily be drawn out. In shop use the rods have a ring at one end, as at E, from which they hang against the wall. This is also used to draw the rod out of the sheet after it is beaded.

GUTTER SUPPORT AND BRACE

The accompanying illustration Fig. 85, shows how to fasten an ogee gutter to a building without disturbing the shingles. Form the sheet metal cylinder just the right length on the gutter beader, then solder the sleeves, which serve as braces, into the gutter at sufficiently frequent intervals to insure support of the gutter without strain when fastened to the building. The fastening is accomplished by a nail about 3-10 × 7 inches, which is driven through the face of the gutter and passes through the sleeve and the back of the gutter and firmly into the fascia or board that finishes the building at the eaves just under the shingles. When a sufficient number of these braces and nails are used experience has shown that good service is rendered.

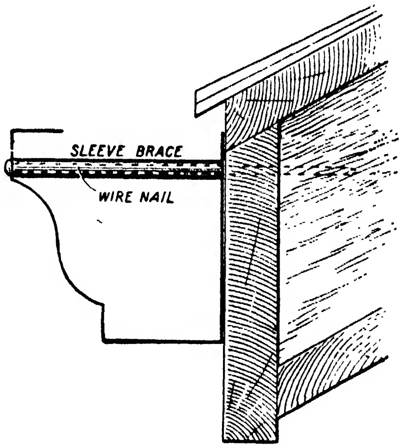


Fig. 85.—Gutter Support and Brace

HANGER FOR EAVE TROUGH

The hangers are easy to make, cheap and durable, and the wind does not blow the trough down let it blow ever so hard. Use No. 19 hoop iron, $\frac{3}{4}$-inch wide, cut 21 inches long, for shortest hanger for the ordinary trough, made from tin cut 7 inches wide. Use No. 18 hoop iron, $\frac{7}{8}$-inch wide, for the trough made from tin

9¼ inches wide. Starting with the shortest strip, cut each subsequent one about ½ inch longer, to allow for fall of trough. Two nail holes are to be punched in each end of the straps, which should be placed about 3½ feet apart on the building. Ordinary hoop iron can be used for the hangers, but if painted or galvanized they

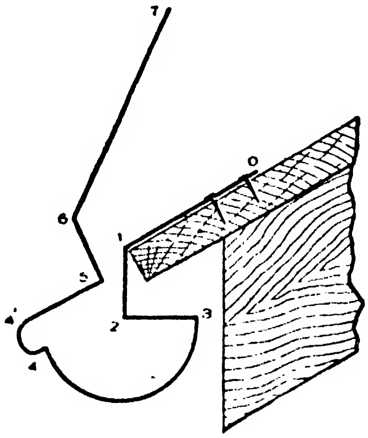


Fig. 86.—Hanger in Position for Receiving Trough

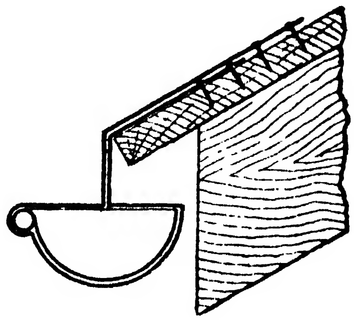


Fig. 87.—The Completed Trough and Hanger

are much more durable. The hangers are formed as in Fig. 86, which shows one in position on roof to receive trough. When forming the hangers, the bends are to be made in the order indicated by the figures; the first bend is made at 1, the second at 2, etc. The increase in length of hangers to allow for proper fall of trough is allowed for between bends 1 2 and 5 6. The hangers having been nailed to the roof, as shown in Fig. 86, and the trough soldered in as long a length as can be handled, the ladder is placed against the building where the center of the trough is to come, and the trough carried up and placed in the hangers. The two nearest hangers are then to be nailed to the roof, when the ladder can be moved to the highest end of the trough and the other hangers nailed as shown in Fig. 87, and so continue until the lower end is reached, when the ladder is in position for putting up the conductor pipe.

A HOME-MADE BEADER

The bed of the machine Fig. 88, is made of a piece of 4 × 6 yellow pine 8 feet 6 inches long. The top of this stands 30 inches above the floor, and is supported by four legs, which are secured to the bed piece by means of bolts running clear through. These legs have a cross brace at the bottom, from which angle braces

run up to the bed piece. On the top of this a piece of 1-inch brass pipe is secured by means of cast iron angle pieces, as shown in Fig. 89. These angle pieces are fastened to the bed by wood screws. Another part of the apparatus is made of a piece of 5-8 inch round machine steel. The piece of steel and a pipe were taken to a machine shop and the pipe had a slot ⅛ inch wide cut in it lengthwise its entire

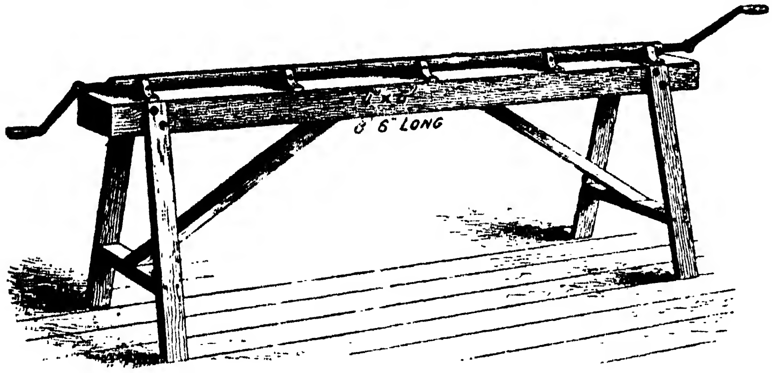


Fig. 88. A Home Made Beader. General View

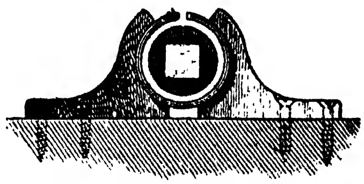


Fig. 89.—Sectional View of Beader and Clamps

length, 8 feet 3 inches. The piece of machine steel had a slot cut in it 1-16 inch wide and ⅛ inch deep for its entire length; and each end was squared so that a crank could be attached to it. After the pipe was fastened to the bed by means of clamps, the steel beader was run through it and the cranks attached, when the machine was ready for use. By inserting the sheet iron in the slot in the beader and by turning the crank at each end so as to reduce the strain on the steel beader shaft, a bead could be formed on a piece of galvanized sheet iron 8 feet long.

A CHISEL TO CUT THE BEAD OF THE PATTERN OF EAVE TROUGH MITERS

Those who have had occasion to make miters in the half round hanging gutters that are generally used know the difficulty and the tediousness of cutting the small curves on the edge where the bead is formed. In the engraving herewith, Fig. 90, is illustrated a steel chisel and is shown a piece of sheet metal along which the miter pattern has been marked out, with the chisel applied to the pattern where the smaller curves occur, so that by one blow from the mallet when the metal is laid on a suitable block, these curves are cut in much less time and with much less labor than would be possible with the ordinary hand snips or bench shears. The chisel is made from a piece of 3-16 × 2½ inch flat steel. The steel has been formed together to make a handle to facilitate its use and a head on which the blow

may be struck. The cutting edge is forged and shaped to the curve desired, after which it is ground sharp to do the cutting. The tool is so simple that it can be readily made by all who desire to benefit by the labor saving attending its use. Of course the balance of the miter is cut with the snips; and it is well to dress down the burr, formed by cutting with the chisel and snips, by laying the material on the smooth surface of a block of cast iron and striking with a mallet the surface of which has been rasped smooth. It is to be understood that such little kinks for the shop as this are of positive value; still it is advisable to install a press (power, if power is available) with the proper dies to cut and prick mark these miters thereby saving time; providing of course that sufficient quantities of gutters, etc., are sold to warrant the investment.

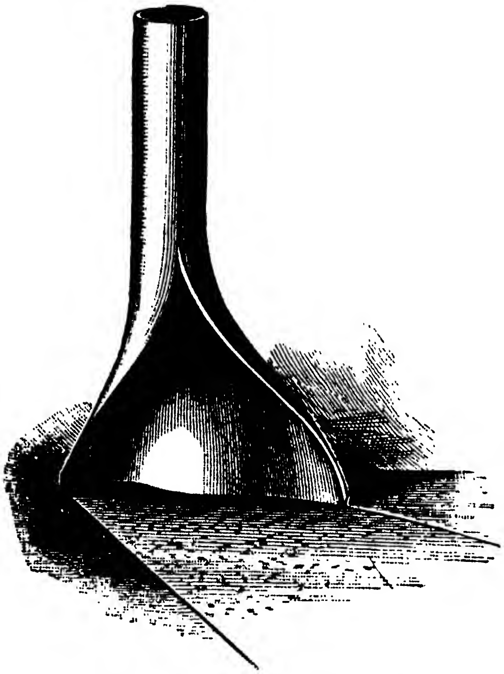


Fig. 90.—Cutting Gutter Miters

HANGING LONG EAVE TROUGH

Many different styles of eaves are met with, and different styles of gutter and hangers are used. In hanging gutter on a barn 80 feet long put up the gutter in two sections of 40 feet each. When the eave projects considerably without

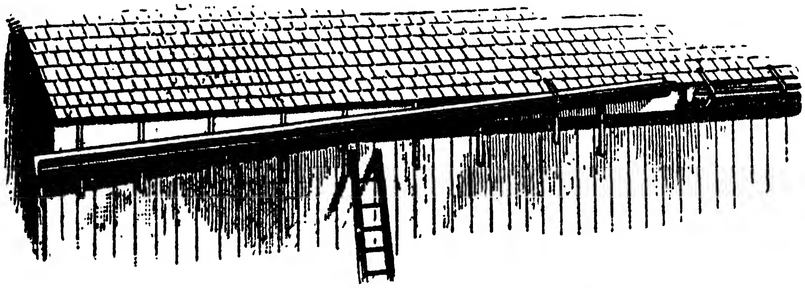


Fig. 91.—Hanging Long Gutters

any back strip nailed to the end of the rafters, always have one put up 6 inches or more wide according to the pitch of the gutter. Then nail gutter straps to it about 2½ feet apart, as shown by Fig. 91. Make them out of good tin painted on both

sides, and cut them 1 inch wide and 28 inches long. At the center of the strap rivet or solder another strap half as long to hold the gutter from being lifted up in a wind storm. Having nailed up the straps make a loop of one, as shown in the illustration, about 10 feet from the high end of the gutter, for the work should always commence at the high end. Now place the ladder about 20 feet from the end and pick up a section of the gutter at the middle of the 40 feet and mount the ladder, when if it is not a windy day, one end of the gutter can be easily pushed through the loop and the gutter secured by another loop near the ladder. After this, by moving the ladder the other straps can be fastened so as to give the gutter a proper pitch, and the first section is completed. The second section is put up in the same way, and when it is secured the two sections are connected and the straps fastened to maintain a proper pitch through the entire length. When all is securely fastened the open seam between the two sections must be soldered; this completes the work ready for the conductor to be attached to pipe at the low end of the gutter. Solder the down straps under the bead of the gutter about 10 feet apart, and when properly nailed they hold the gutter securely in place, and the strongest wind will not lift the gutter out of the straps or destroy the pitch.

HOLDER FOR EAVE TROUGH

For a holder when soldering eave trough, make a sheet-iron cylinder, A B C, Fig. 92, the diameter of gutter and 4 feet long, or longer if desired. Form a strip of iron the length of cylinder and rivet to same, as shown at D. This forms a straight edge for the bead on trough to rest against. Then form two or more wire springs, as shown by E F G, for holding the trough in position while soldering. These springs are to be hinged to the cylinder as at G, and bent so as to go over the bead and lock over D, as shown at E. The springs are hinged at G, so they can be turned back to release the trough after it has been soldered. Then cut two disks from 1-inch board to fit in the ends of cylinder and which can be secured in place by nailing. In the center of each disk, as at M, drive a wire for the cylinder to revolve on. A 6-inch board, K L, for stand, and two 8-inch uprights, similar to H J, complete the machine.

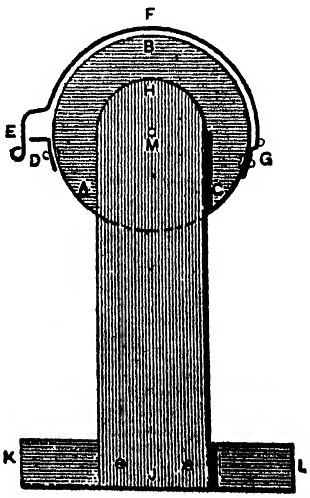


Fig. 92.—Holder for Eave Trough

EAVE TROUGH HANGERS

Pieces of tin that are from 18 to 20 inches long are cut into strips 1 inch wide and used for stays, as shown by A in Fig. 93. These stays are brought around under trough, nailed to cornice, and placed 6 or 8 feet apart. Shorter strips, from 10 to 16 inches in length, are used for the uprights B, and are bent around the cross bars C and soldered to same. The cross bars C are made from pieces of tin $1\frac{1}{4}$ inches wide, and from 3 to 6 inches long, according to the size of trough they are intended for. These cross bars are formed in triangular shape, placed with the opening down, in top of trough, and soldered at the ends. D represents a piece of $1\frac{1}{4}$-inch hoop iron cut 10 or more inches long, having a slot in one end and provided with holes for nailing to roof. D is nailed to the roof, as shown in Fig. 94, the upright B passed through the slot and drawn up so as to give the trough the proper slant. The upright B is then cut off 1 inch above D, the ends bent over each way and under, being pinched close

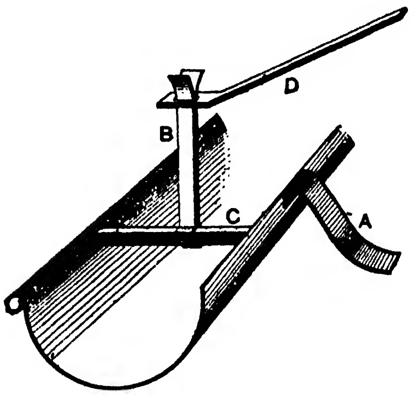


Fig. 93.—Eave Trough Hangers. Various Parts of Hangers

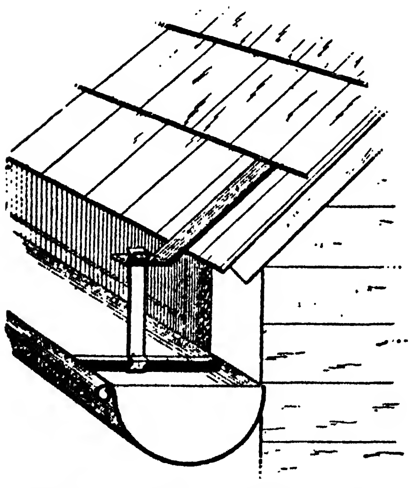


Fig. 94.—Trough Attached to Roof

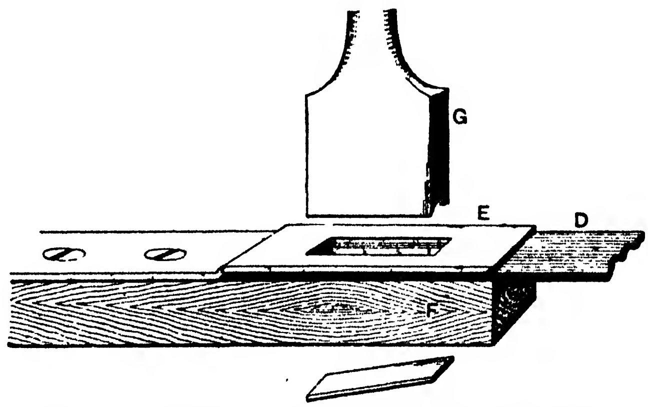


Fig. 95.—Die and Punch for Cutting Slots in Band Iron

with the flat pliers. In Fig. 95 is shown the die used for punching the slot in the end of hoop iron. The die is represented by F and attached to it is the guide E, which allows the hoop iron D to pass in the proper distance and insures the punch being placed over the opening in die. The punch G is represented in proper position for punching the band iron D. The punch and die can be made by any blacksmith and should not cost over 50 or 75 cents.

AN EXPANSION JOINT FOR GUTTER LINING

The greatest trouble in using copper is in making the proper provision for taking care of the contraction and expansion, and in this connection it is well to remember that this is much greater in copper than in any of the other materials used for lining gutters.

Copper expands or contracts 0.0115 inches for each 100 feet of length for each degree of difference in temperature. This means that a piece of gutter lining 100

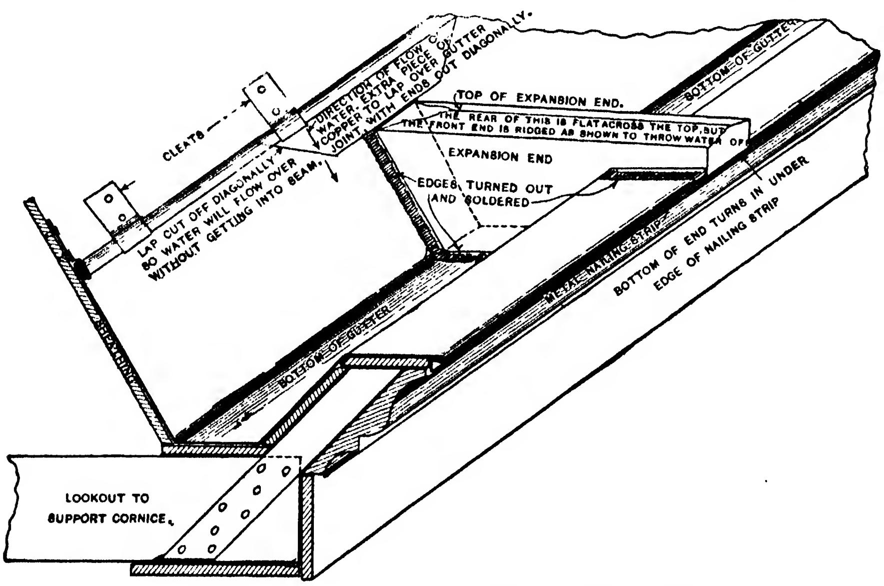


Fig. 96.—Arranging for Expansion in Copper Gutter

feet long will expand nearly $1\frac{1}{6}$ inches in length in a difference of 100 degrees of temperature. As the actual difference between the extremes of the coldest weather in winter and the hottest weather in summer is considerably more than this, the amount to be taken care of is still more than the amount stated above.

It is probably safe to assume that the maximum variation in temperature from the coldest weather in winter to the hottest weather in the sunshine in the summer will be 150 degrees. On this basis, it will be seen that the amount of expansion in a gutter lining 100 feet long will be 1.725 inches, or practically $1\frac{3}{4}$ inches. Now, if this gutter is put in during the maximum heat of the summer, without making provision for the contraction, it will be found that a number of the seams will be broken from the strain put on the gutter by the contraction of the copper, which will be shortened $1\frac{3}{4}$ inches, as there is no way to prevent the contraction. On the other hand, if the gutter is put in during the severe weather of the winter,

without making provision for expansion in the summer heat, this expansion will add 1¾ inches to the length of the gutter, which will cause it to buckle up in heavy ridges, and then the contraction of the copper will cause these ridges to crack. Obviously the proper way is to exercise judgment and common sense in using this material and to take into consideration the temperature prevailing when the gutter is put in.

Regardless of the temperature neither edge of the gutter should be nailed under any circumstances. The outer edge should be locked to a strip nailed to the outer edge of the gutter board and should be locked so it can slide along freely when contracting or expanding.

The inner edge should have a half-inch turned and should be cleated. All cross seams should be heavily tinned on both sides of the metal before being edged;

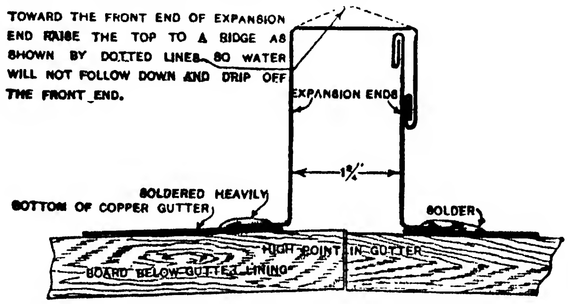


Fig. 97.—Gutter Expansion Joint in Cold Weather

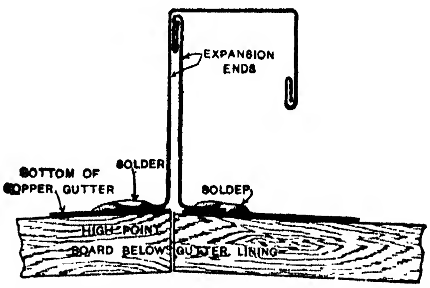


Fig. 98.—Gutter Expansion Joint in Hot Weather

the edges should be ½ inch wide, the lock well hammered down and heavily soaked with solder. Too much stress cannot be laid on thoroughly tinning the sheets on the ends for the locks, turning edges ½ inch wide and soaking the solder in well, for these seams are subjected to great strain. If there is very much of this work it would be best to tin the sheets on the ends by dipping them and then letting as much of the solder as will cling to the ends of the sheets remain on them. Then, when the seams are soldered, this solder amalgamates with that soaked into the seam and makes a solid joint all the way through.

So far the preparations and instructions are the same, regardless of the season, but the work at the job must be carried out with due regard to the temperature. For instance, if the gutter lining is put in when the temperature is at the lowest that it is likely ever to be it will not be necessary to make any provision for contraction, but a piece of gutter 100 feet long should be free at one or both ends to the extent of 1¾ inches or ⅞ inches for a gutter 50 feet long.

Supposing we have a piece of gutter 100 feet long, draining to both ends, with a high point in the center. We should put this in place in two pieces which

will lack at least 1¾ inches of coming together, and then we should solder an end piece in each gutter at the high point, with the top of this piece as high as possible, but at any rate at least 1 inch higher than the outer edge of the gutter. (See Fig. 97). These two end pieces should be set not closer than 1¾ inches, as in the warmest of the summer weather the expansion of the copper will be sufficient to bring them together.

The part of the rear of the gutter which extends above the end pieces should be lengthened by soldering on an extra piece until it will lap over on the other piece about as shown on Fig. 96; but it should not be soldered to this piece on both sides, but left free on one side for expansion and contraction. This should also be cut off on a bevel at the end, as shown, so the water will run across the seam. One of these ends should bend over on top square 2 inches and then turn down 1 inch or more to keep the water from getting in between the two end pieces. A section through these joints would show like Fig. 97. This shows the positions of the ends when the temperature is lowest.

In the hottest weather of summer they will be close together, like Fig. 98. If the gutter lining is put in during the hottest summer weather the ends should be close together, as shown in Fig. 98, as the lining gutter will then be at its maximum length and all the provision should be made for contraction.

As the gutter lining will seldom be put in during either extreme, it will be necessary to use judgment, and to decide according to the temperature prevailing how much of the allowance should be made for expansion and how much for contraction. In considering this the writer assumes that the lowest temperature to which the gutter lining will be exposed will be 30 degrees below zero and that the maximum will be 120 degrees. Then, when putting in gutter lining when the temperature is about 45 degrees above freezing point, we would make equal provision for expansion and contraction, and in placing the two ends would set them ⅞ inches apart, which would give us an allowance of ⅞ inches for expansion and ⅞ inch for contraction.

In figuring on copper work it is necessary to figure that the labor will cost considerably more than for tin as it requires more time to do the work, and in addition to this the man who pays a "copper price" expects "copper quality," and he is entitled to it. Great care should be taken to get the material in smooth and free from buckles, as these mean broken places in the gutter. If these directions are followed there should be no complaint where copper is used, and it should last indefinitely and without expense for painting and repairing.

GUTTERS IN WOOD WORK

Two different types of boxed-in gutters, designed not only to carry away rainfall but also to prevent any damage by snow slides, are the subject of the accompanying illustrations. On flat roofs having a slope of less than 2 inches to the foot there is, of course, no need for protection against snow slides—at any rate in the case of porch roofs where the snow will melt and run off before it slides. The gutter shown in Fig. 99 is finished with 20 × 28 inch terne plates made up in rolls 28 inches wide. The strip of tin extends upward underneath the shingles about 12 inches at the high point of gutter and about 6 inches at the low for it s not necessary to trim unless it is desir-

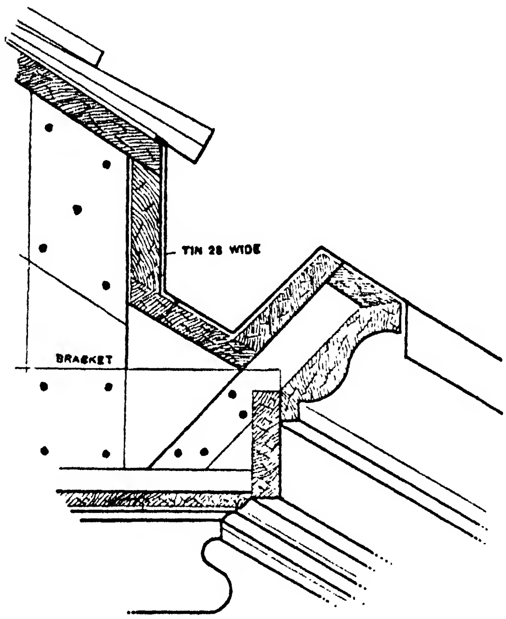


Fig. 99.—A Cornice Gutter

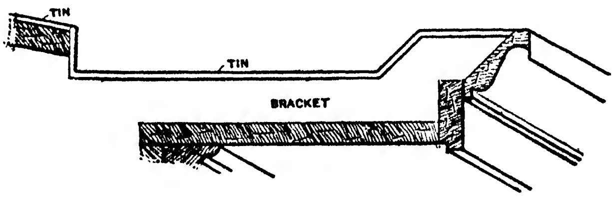


Fig. 100.—Gutter on Porch Roof

able to have the waste tin; where it is fastened. While the low er edge projects straight downward over the cornice, forming a drip edge, so that water collecting toward the edge of the gutter can fall clear of the cornice. This makes a gutter wide and deep enough for an ordinary roof. If a more ornate finish is desired it may be secured by soldering a ½-inch roll on the drip edge described, this arrangement not interfering with the free fall of the water.

The gutter shown in Fig. 100 is applicable to flat roofs. The particular style as a part of a porch roof, made wide to accommodate the architectural conformation of the bracket and cornice. This is a form of construction such as may be used to extend an old roof line to improve appearances. The tin of the roof is formed into the shape of a gutter on the new wood work and carried over the edge of the cornice, as in the case of the gutter shown in Fig. 99. The gutter of this description provides a wide waterway and can be easily placed on an old building to take the place of a hanging gutter.

FORMING RIDGING AND GUTTERS ON THE CORNICE BRAKE

When a ridge roll is to be formed, as shown in Fig. 101, the operations are similar to those shown in Figs. 102 to 105, inclusive.

First, find the girth of the ridge roll shown in Fig. 101 and make the square bends as indicated by 1 2 3 and 6 7 8 in Fig. 102. Place 1 2 3 in the recess between the top clamp B and the bottom clamp C, as shown by 8 1, and close the top clamp B on dot 4. Then make a square bend, as shown by A 1. Leaving the sheet in this position as shown by A 1 in Fig. 103, place the required size former *a* in position, fastening it by the clamp *b*. Press down A over the former until it has the position shown by B.

Release the former and reverse the sheet and place it in position, as shown by B 1 in Fig. 104. Close the top clamp on dot 5′ and make a square bend, bringing the sheet in the position shown by 1° B. Leaving the sheet in this position place the former *a* in position as shown in Fig. 105, and press down 1° until it strikes the clamp *b* at *c*. Remove the clamp *b* and press C in its proper position, shown by D, which completes the forming of the ridge roll shown by 1 8 in Fig. 101.

In Fig. 106 is shown an O G gutter with beaded or wired edge on the outside. Obtain the girth of the gutter and bead the edge in the usual manner, after which place the sheet in the brake in the position shown by 1 8 in Fig. 107. Close the top clamp on dot 2 and make a square bend as shown by 1° 8. Now tip the bending leaf A in Fig. 108 as shown and place the sheet 1° 8 in Fig. 107 in the position shown by 1° 8 in Fig. 108. Then by gradually drawing out the sheet to dot 3 and closing the top clamp at each division between C and 3° the position 1°, *a*, *b* and C are obtained when the dot 3 reaches 3°.

Do not take out the sheet, but close the top clamp on dot 4, as shown in Fig. 109, by C 8, and make a square bend, bringing the sheet in position shown by A 8. Leaving the sheet in this position, as shown by A 8 in Fig. 110, fasten the former *a* by the clamp *b* and draw A in the position shown by B 8. When making this curve care should be taken not to pull down at *d*, for this would bring the upper curve *d* 3′ between 3′ and 4 in the direction of the arrow, until the vertical pressure at *i* completes the mold and 3′ touches the former at 3°. The rest of the bends shown by 5, 6 and 7 in Fig. 106 are bent in the usual manner.

When a half round gutter, shown in Fig. 111, is to be formed on the brake the method to be used is that shown in Figs. 112 to 115, inclusive. After the

wired edge has been turned on the gutter shown in Fig. 111 place the sheet in position, as shown by A 3 in Fig. 112, and tipping the bending leaf slightly as was

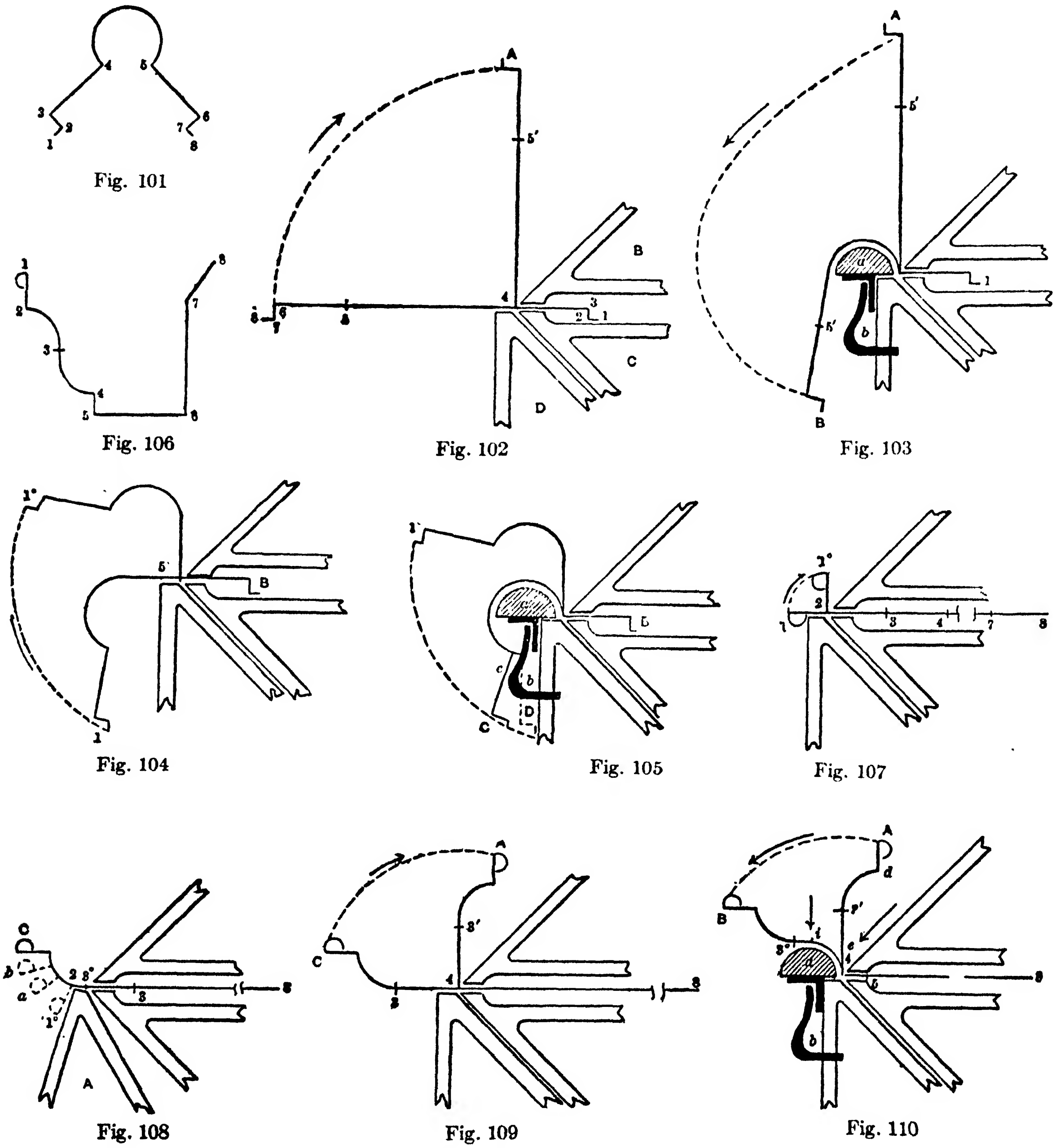


Fig. 101 Fig. 106 Fig. 102 Fig. 103 Fig. 104 Fig. 105 Fig. 107 Fig. 108 Fig. 109 Fig. 110

Method of Forming Ridging and an Ogee Gutter

done at A in Fig. 108 obtain a slight curve to the front part of the gutter. Now reverse the sheet and place it in position, as shown by B 3 in Fig. 113, close the clamp on dot 2 and make a square bend, as shown by A 3.

Leaving the sheet in this position, as shown by A 3 in Fig. 114, fasten the required size former *a* and draw A over the former until it has the position shown by B. The former should be smaller than the profile of the gutter, as the metal will spring back again after being drawn over the former. By referring to Fig. 111 it will be seen that the angle at 2 is not a square bend, and as a square bend

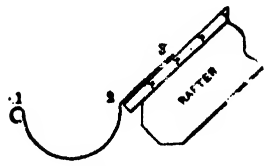


Fig. 111

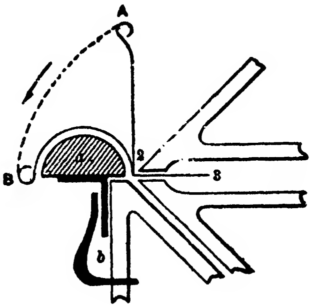


Fig. 114

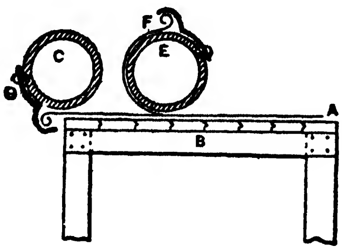


Fig. 117

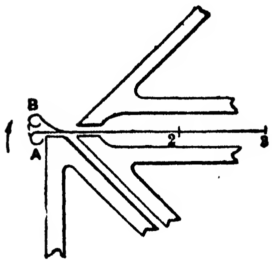


Fig. 112

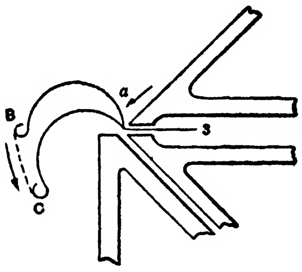


Fig. 115

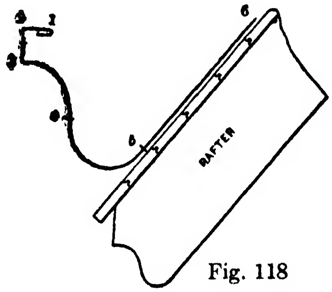


Fig. 118

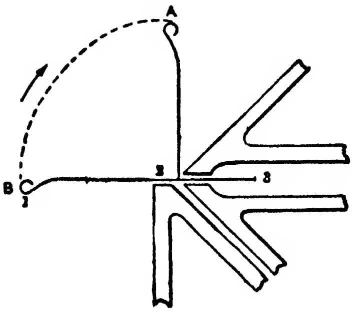


Fig. 113

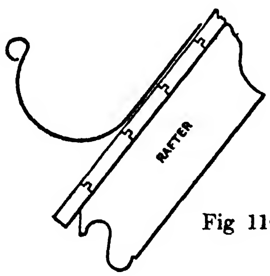


Fig 116

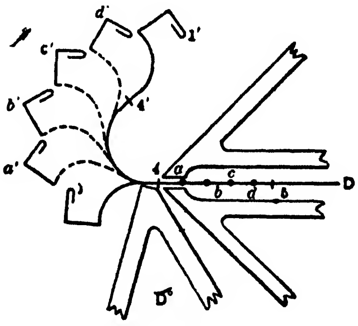


Fig. 119

Method of Forming Different Types of Gutters

is shown at 2 in Fig. 114, release the former so that the sheet will appear as shown in Fig. 115 by B. Then press it down in the position shown by C, or until it has the proper angle, being careful that the pressure is exerted at *a*. This completes the forming of Fig. 111.

Fig. 116 shows another shape of gutter on which no bends are required. This shape could be formed in a manner indicated in Fig. 108, but a quicker and simpler way is shown in Fig. 117, which is also applicable to the gutter shown in Fig. 111.

First, bead the gutter in the usual manner and place it upon the bench B in Fig. 117, as shown by A. Now obtain an iron pipe or wooden roll, C, of the required size and length, being careful to have them a trifle smaller than the profile, because the metal will spring, and fasten—say, at distances of 3 feet apart—clamps as shown at D, the clamp to catch under the bead as shown. Now if two or three men (according to the thickness of metal used) spread their arms, grasp the pipe firmly and slowly roll it over until the desired position F is obtained the gutter will be finished so far as the forming of the roll is concerned. In this manner the form shown in Fig. 116 is obtained. If Fig. 117 were to be used for the form shown in Fig. 111 a bend would be made in the brake on dot 2, as shown by C 3 in Fig. 115.

Fig. 118 shows another form of O G roof gutter, the method of forming which is practically the same as that for the gutter shown in Fig. 106. The final processes, however, are shown in Fig. 119. Starting at dot 4, which corresponds to dot 4 in Fig. 118, space the distance between 4 and 5 in Fig. 119 into equal parts, as shown by *a b c d* 5. Draw out the sheet to dot *a* and slowly but firmly close the top clamp, when the gutter will have the position shown by a'; then draw out to dots *b c d* and 5, always closing the top clamp at each dot, when the gutter will appear, as shown respectively by b' c' d' and $1'$. Then $1'$ D will be the desired shape to correspond to Fig. 118.

It should be understood that the higher the bending leaf D° is raised the closer the divisions are made between 4 and 5 and the tighter the top clamp is closed the smaller will the circle be, while if the bending leaf D° is tipped very slightly, the divisions between 4 and 5 being less in number, and the top clamp closed lightly, the larger will the circle be in the gutter. Experience and practice will show the various operations to use in bending the various size molds and curves.

PATTERNS FOR GUTTER MITERS ON ROOFS OF DIFFERENT PITCH

One roof is half pitch, as shown by A B C in the accompanying illustration, and the other is one-third pitch, as shown by A^1 J^2 I, Fig. 120. The shape of the gutter is shown by the profile M on the half pitch roof, and is the given profile.

For the benefit of readers who do not understand about roofs of one-half

and one-third pitch we will explain how these pitches are determined. By a roof of one-half pitch it is understood that the vertical hight A J is equal to one-half the width of B C, while a roof of one-third pitch is understood to be one where the vertical hight is equal to one-third of its width.

The first step is to draw any line, as B C, which bisect, thus obtaining the point J. At right angles to B C and from J erect the line J A, equal to B J or J C. From A draw lines to B and C; then will A B C A represent a roof of one-half

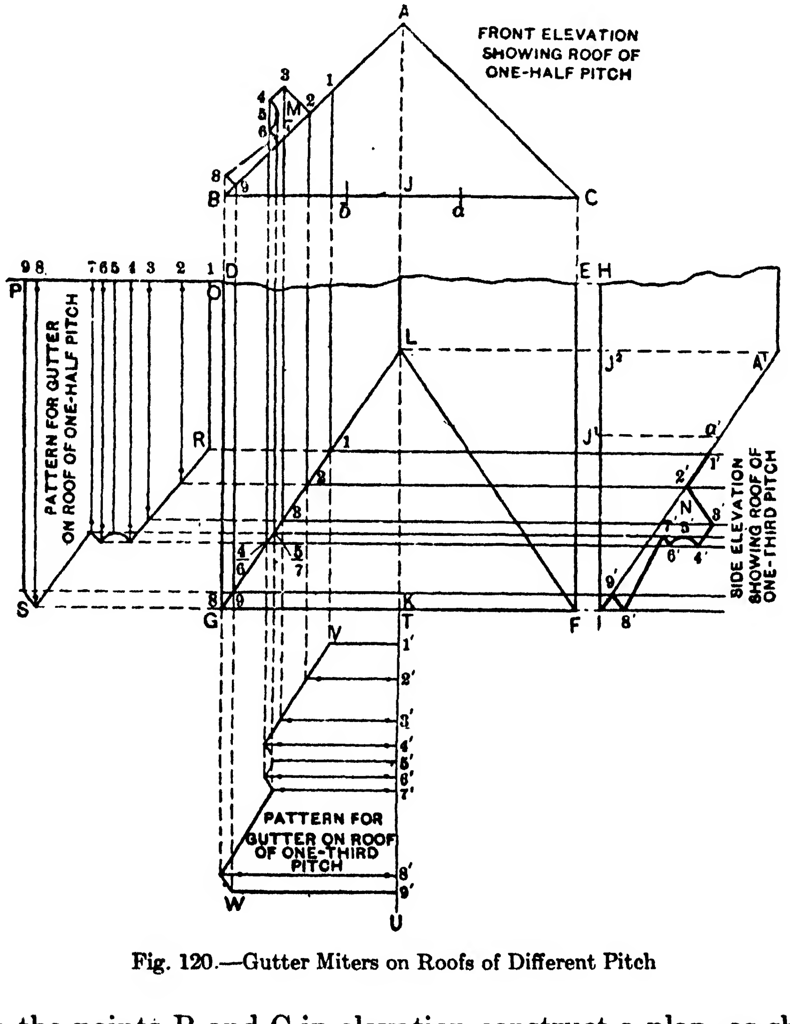


Fig. 120.—Gutter Miters on Roofs of Different Pitch

pitch. From the points B and C in elevation construct a plan, as shown by D E F G, and parallel to E F in plan draw the line H I, as shown. Transfer the distance from C to J in front elevation, placing it as shown from I to J^1 in side elevation, and divide the line C B into three equal spaces (for one-third pitch), as shown by *a b*. Take the distance of one of these spaces, as C *a*, and place it as shown by

J^1 a' in side elevation, at right angles to J^1 I. Draw a line from I to a', extending it until it meets the line drawn at right angles to H I, equal in length to J A in front elevation, as shown by J^2 A^1 in side view. Then will J^2 A^1 I be the side elevation of a roof having one-third pitch.

From A^1, at right angles to H I, extend the line A^1 J^2 until it meets the center line A K in plan L. Draw a line from L to G and L to F, which will represent the roof plan of the two pitches. Let M be the given profile of the roof gutter placed upon the roof having one-half pitch, or it could be placed upon the roof of one-third pitch if desired. As the roofs are of different pitches, it will be necessary to obtain a modified profile on L K in plan, to admit the mitering at the hips L G and L F.

To obtain this modified profile, divide the profile M into equal spaces, as shown by the small figures 1 to 9. At right angles to B C and from these small figures drop lines intersecting the hip line L G in plan, as shown. From these intersections and parallel to G F draw lines indefinitely into the side elevation, as shown. Now, measuring in each and every instance from the line B C in front elevation, take the distances to points 1 to 9 in the profile M and place them on lines of similar numbers in side elevation, measuring in each and every instance from the line H I, thus obtaining the points shown from 1′ to 9′. A line traced through these points will be the modified profile through L K in plan.

For the pattern for the gutter on the half pitched roof, draw any line, as O P, at right angles to D G, upon which place the stretchout of the profile M, as shown by the small figures 1 to 9. At right angles to O P and through these small figures draw lines, which intersect with lines drawn from intersections having similar numbers on L G in plan, at right angles to D G. Trace a line through these points; then will O P R S be the pattern for the gutter on roof of half pitch, formed after the profile M.

For the pattern for gutter on the roof of one-third pitch, draw any line, as T U, at right angles to G F, upon which place the stretchout of the profile N, as shown by the small figures 1′ to 9′. At right angles to T U and through these small figures draw lines, which intersect with lines drawn from intersections having similar numbers on L G in plan, at right angles to G F. Trace a line through the points thus obtained, and T U V W will be the pattern for the gutter on the roof having one-third pitch, formed after the profile N.

PATTERNS FOR THE MITERS OF A GUTTER MOLDING

The accompanying illustration, Fig. 121, shows how an inside and outside right angle miter can be obtained. Let A represent the profile of the gutter mold, placed upon the proper pitch of the roof, as shown. Divide the mold A into equal spaces, and place its girth upon the vertical line B C, through which horizontal lines are drawn and intersected by vertical lines dropped from similar numbered points in the mold A. A line traced through points thus obtained, as shown by D E, will be the miter cut, and E B C D will be the outside miter cut and E D G F the inside miter cut.

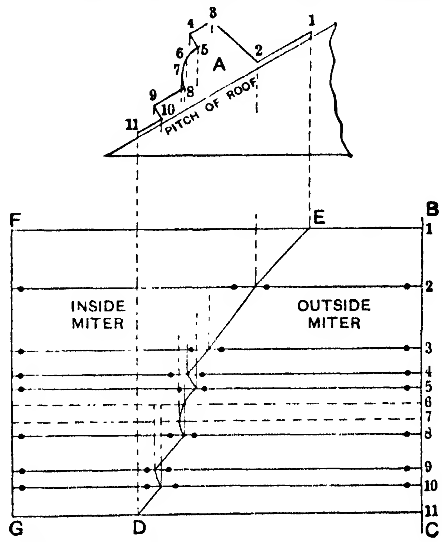


Fig. 121.—Obtaining Miters for Gutter Molding

The required pitch, so as to have water run to the outlet, would be made in the part numbered 1 2 3, and will necessitate but a slight change of procedure to obtain the miter cut of the pattern for that part.

PATTERN FOR EAVE TROUGH MITER AT ANY ANGLE

A simple way to lay out gutter of any size and cut the patterns for it, at any angle, is to lay out line A of any length, sufficient to give the width of the gutter desired, Fig. 122. About the center of this line set compasses with one leg on the line at B, and the other extended until it will mark the radius of the gutter. In this instance laying out a 5-inch half round gutter, so the compasses should be set to a radius of 2½ inches and a half circle struck.

Strike line C C parallel with A A and as far from it as half the diameter of the bead of the gutter will be. With 5-inch gutter the bead is generally ½ inch. Half of this is ¼ inch, therefore C C will be ¼ inch from A A and parallel with it.

Set the compasses to ¼ inch and move them along on line C C until the outer leg of the compasses touch the outer radius of the gutter, and with this as a starting point and D as a center, draw a circle for the bead of the gutter, and then add the tongue of the bead, which should be just the width that your beader slot will take.

Parallel to line A A and at any convenient point lay out line E E about 11 or 12 inches long.

Beginning at the inner edge of the tongue of the gutter bead mark this edge No. 1, set the compasses with the leg on 1 and the other at the bend of the tongue, which will be called 2.

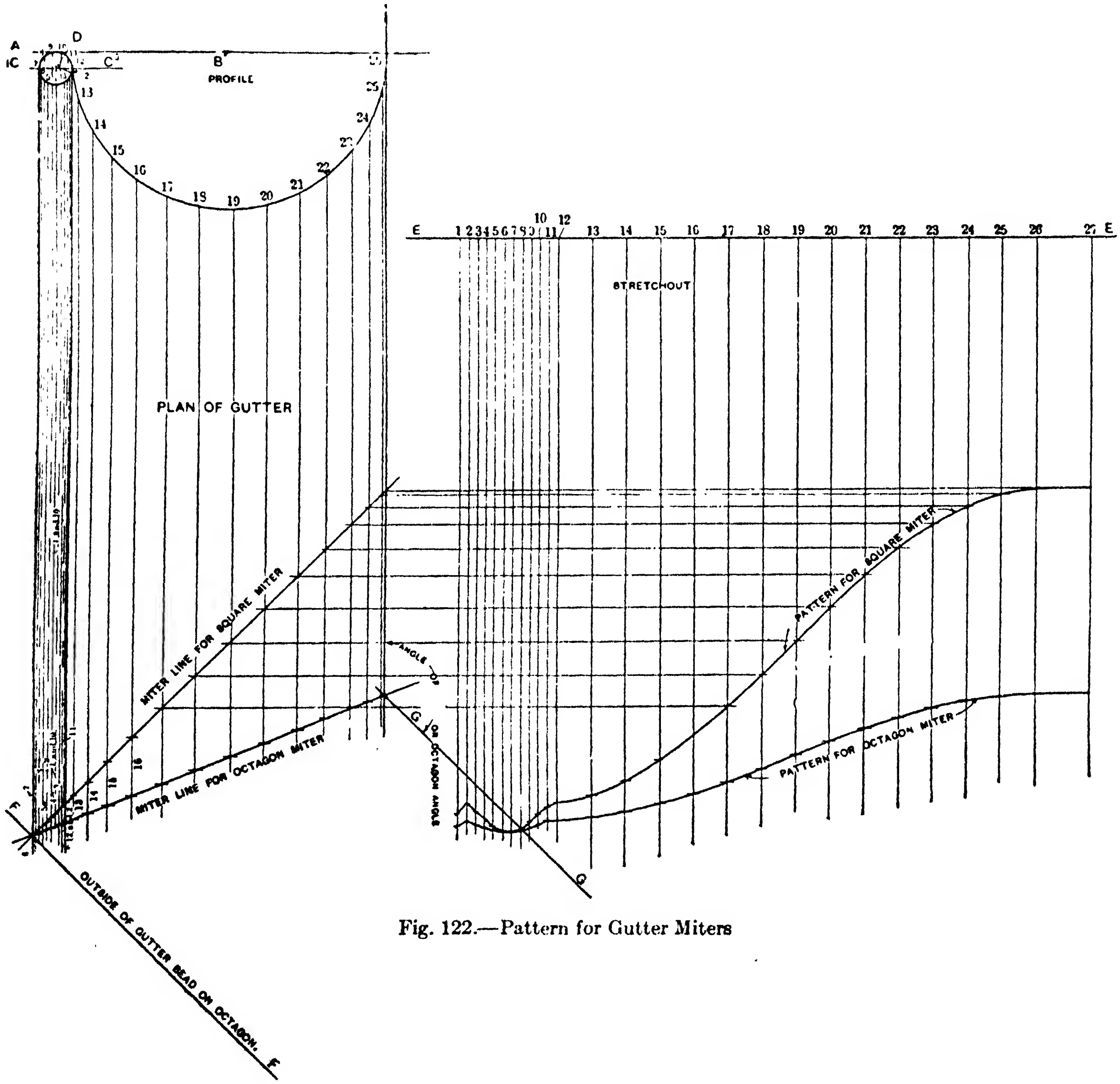


Fig. 122.—Pattern for Gutter Miters

With the compasses set as above, carry them over to line E E and set them down. Mark the two points made by the legs 1 and 2 the same as on the profile.

Carry the compasses back to the profile, leaving them set as for 1 to 2, or set wider if desired to make the spaces longer, and successively set off 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12 on the bead, each of these distances being the same as from 2 to 3.

Mark off these spaces on line E E immediately following 1 and 2, already laid off, and number them successively from 3 to 12 as shown.

The spacing on the gutter proper need not be so close as on the bead, because the gutter does not change direction so sharply as the bead, therefore set the compasses for increased distances, as shown from 12 to 13, and proceed to divide the gutter up into equal spaces, as shown by 12 to 26, inclusive, and these spaces set off on line E E.

This leaves one space to be determined yet, and the stretchout is measured first so as to make the space 26 27 take up balance of required girth. If it is desired to make gutter out of 10-inch girth measure on stretchout 10 inches from 1 and mark same 27 on line E E of stretchout. Set the dividers so as to get the space from 26 to 27 and then mark this distance on profile from 26. This brings the back of the gutter in this case ¾ inch higher than the front, which is a good point as it will insure the water being thrown away from the building if the gutter ever overflows on account of the leaders being clogged or frozen, instead of overflowing on the rear edge and wetting the walls of the building.

In laying out the spaces on a stretchout it is not necessary, as many suppose, to make the spaces come out just even. Many starters at pattern cutting are perplexed by this and space off the profile time and again in an effort to make the last space come out the same as the others. The proper method is to lay out as many spaces as may be required for that surface and lay them all out the same distance except the last one.

These are stepped off on the stretchout, and then the dividers are changed to suit the last space, and it is stepped off and set down on the profile. It is only for convenience in laying out the work that the spaces in any curved surface, as from 12 to 26, are made the same. They could all be made different, but this would make more trouble in laying them out on the profile and on the stretchout, a this would require the dividers to be changed for each space. What is necessary is to space corresponding points exactly the same on the profile and on the stretchout.

Having done the spacing properly on both the stretchout and the profile and numbered all the points as they should be and as shown on accompanying sketch, take the square or T square, and from the points obtained and at right angles to A A and E E, draw lines indefinitely as shown. These lines drawn from

the profile of the gutter give the plan of same, and a line drawn across this gutter with a 45-90 degree triangle will give the miter line for a square miter.

To get the angle for an octagon miter use the same triangle and draw line F F crossing line 7 of the plan. Parallel with line F F and exactly as far as from it as line 26 on the plan is from line 7, draw line G G. Where F F and G G intersect with lines 7 and 26 marks the beginning and end of the miter line for octagon miter, as shown on sketch. These two miter lines, marked "miter line for square miter" and "miter line for octagon miter," show in the plan just exactly the way the gutter would appear if it were cut off to a square or an octagon miter if we were looking down on it.

From the points where the lines in the plan cross the miter lines carry lines, at right angles to the plan, across lines of the corresponding numbers in the stretch-out, and a line traced through these intersections gives the correct pattern, to which should be added (on half the pieces cut) the edges, or laps, desired.

In the sketch the lines are carried across the stretchout to the corresponding lines in the stretchout, but it is not necessary, and is really confusing at times, to have so many lines, as all we really need to mark down are where the ines cross corresponding lines in the stretch out, as shown by the short lines crossing 1 to 16, inclusive. This method allows of cutting the pattern for any angle desired, and if the reader has no triangle he can get his miter lines by using a bevel set to the proper angle. For instance, with his bevel set for an octagon angle he can mark line F F, and parallel with it and at the exact distance from it that line 7 is from line 27 he can set off line G G, and where these intersect with lines 7 and 27 on the plan he traces his "miter line for octagon miter."

PATTERN FOR GUTTER MITER OR HIPPED ROOF

For the patterns for a roof gutter on a square hipped roof which has a one-fourth pitch, the gutter having a profile as shown by A B in the accompanying illustration, Fig. 123.

This miter should be developed the same as a return miter, and a mistake in problems of this nature, is often made in not placing the profile of the gutter in its proper position, as shown correctly in the sketch. The first step

is to draw correctly the pitch of the roof. This is done by making *d c* equal to one-fourth of any line *a b*, or, in other words, the rise *c d* is equal to one-fourth the span *a b*. Then *a c* or *c b* represents a one-fourth pitch. Now draw the desired profile A B, which then divide into equal spaces, shown from 1 to 13. Draw the stretchout line C D at right angles to *a b*, upon which place the girth of the profile A B, as shown from 1′ to 13′. Draw the usual measuring lines, which intersect by lines drawn parallel to C D from similar numbers in the section. Then will C D E F be the desired pattern.

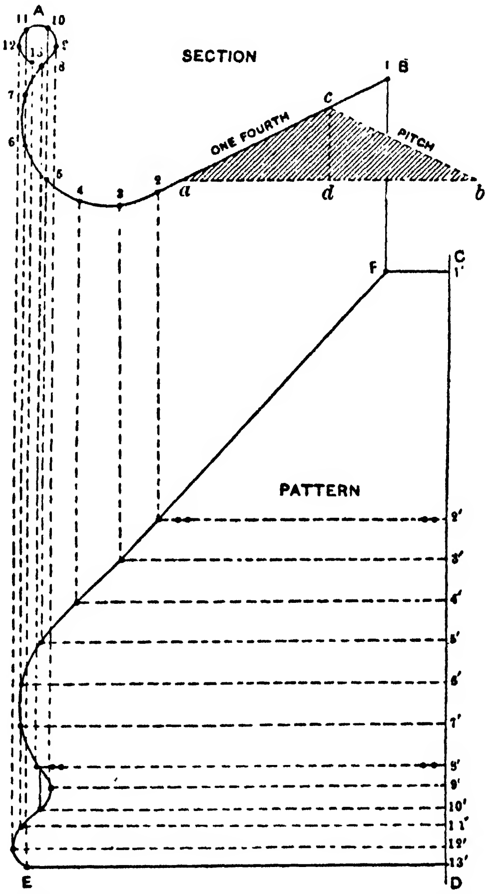


Fig. 123.—Pattern for Gutter Miter on Hipped Roof.

PATTERN AT ANY ANGLE FOR OGEE GUTTER

In the accompanying illustration Fig. 124, is shown the principle used in developing the pattern for a gutter at any desired angle. In this case the angle B C D has been made 45 degrees, but the same principle is used, no matter what degree the angle may have. First draw the profile of the gutter, shown by A, which divide into equal spaces, shown from 1 to 11. Place the desired angle B C D in line with 2 3 of the profile, as shown. Having the angle in its proper position the next step is to obtain the miter line C *c*. This is done by using C as center, and with any radius describe an arc intersecting B C D at *a* and *b*. Using *a* and *b* as centers, with the same or any other radius describe arcs intersecting each other at *c*. Draw the line C *c*, which is the miter line desired.

From the various points 1 to 11 in A drop vertical lines intersecting the miter line C *c* from 1 to 11. At right angles to B C draw the line B E, upon which place the girth of A, as shown from 1 to 11, from which at right angles to E B draw lines, which intersect by lines drawn parallel to E B from various intersections on C *c*,

resulting in the intersections shown. A line traced through the points thus obtained, as shown by F H, will be the desired miter cut. As the wall line is shown

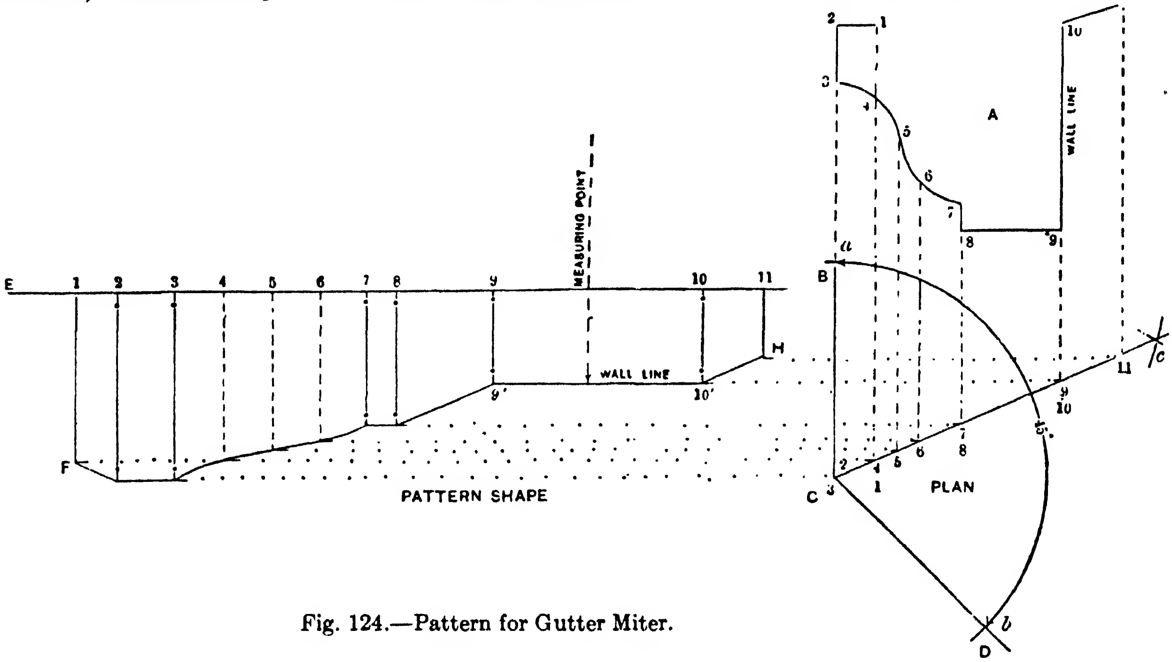


Fig. 124.—Pattern for Gutter Miter.

from 9 to 10 in A then will 9′ 10′ in pattern be the line from which measurements are made.

PATTERN FOR RAKING EAVE TROUGHS

To get the miter patterns where the horizontal half round eave troughs A B and C D in Fig. 125 join the raking trough, proceed as follows:

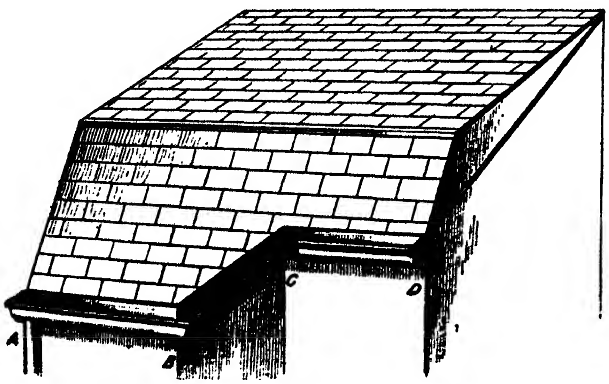


Fig. 125.—Perspective of the Eave Troughs.

In Fig. 126 draw the plan A B C D, showing the angles of the wall, and above the same draw the side elevation A^1 B^1 C^1 D^1, in which 12 H represents the pitch of the roof and E and E^1 the given profiles of the horizontal eave troughs at bottom and top, respectively. As the inside cut of the miter B in Fig. 125 will answer for the miter C, it is necessary only to obtain the pattern for the lower miter, B.

Divide the trough E in Fig. 126 into parts as shown from 1 to 12, allowing

a flange, 12 13, on roof. Through 12 draw the horizontal line F G, and from any convenient point, as F, erect F H, intersecting the pitch of the roof at H. Bisect angles A B C and B C D in plan as shown, and draw the miter lines *f* 3 and C *c*. Through the points in E draw vertical, lines, cutting G. F and *f* 3, as shown, and at pleasure draw the horizontal line K L.

For the miter patterns for the horizontal troughs at B and C in Fig. 125, draw any horizontal line, as K L in Fig. 127, upon which place the stretchout of the profile E in Fig. 126, and draw the vertical lines in Fig. 127, as shown. Now, measuring in each instance from K L in Fig. 126, take the various distances to points 1 to 13 on the miter line 13 3 and place them on similar numbered lines in Fig. 127, also measuring in each case from K L Through points thus obtained, trace the miter cut C D. Then will 1 C D 13 be the pattern for the horizontal trough A B, and C F E D in Fig. 127 the pattern for the horizontal trough C D.

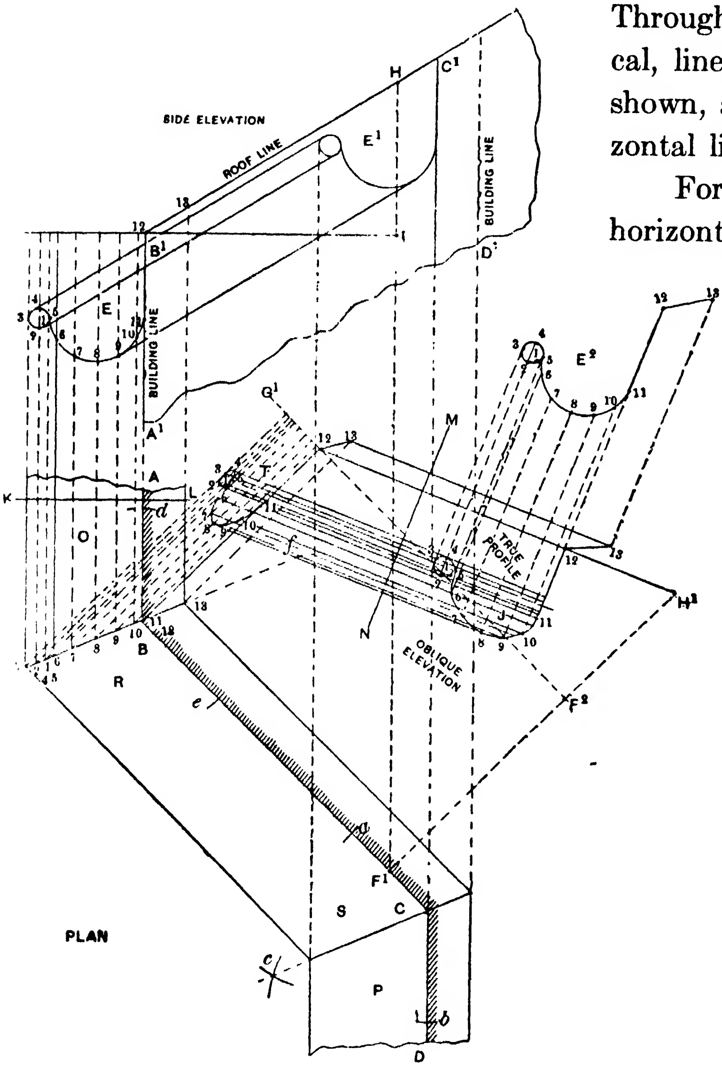


Fig. 126.—Drawing of Projections.

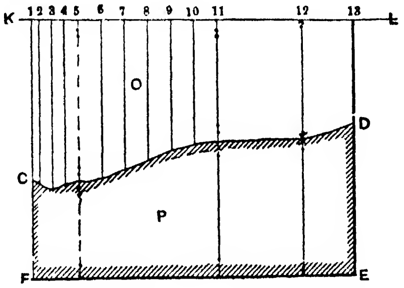


Fig. 127.—Patterns for Horizontal Gutters.

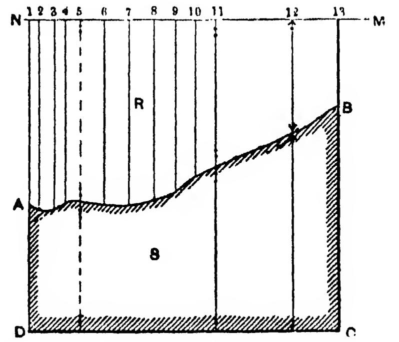


Fig. 128.—Patterns for Raking Gutter.

Before obtaining the pattern for the raking trough an oblique elevation and true profile through same must be obtained. Parallel to B C in plan in Fig. 126, draw G^1 F^2, perpendicular to which and from 12 in plan erect a line, intersecting G^1 F^2 at 12. Extend the line H F until it cuts the wall line B C in plan at F^1, and from F^1, perpendicular to B C, erect a line, intersecting G^1 F^2 at F^2. Extend it so that F^2 H^1 will equal F H in side elevation. Draw H^1 12, which is the true pitch of the roof on B F^1 in plan. From the various intersections on 13 3, at right angles to B C, erect lines meeting G^1 F^2, as shown. Then, measuring in each instance from the line G F, take the various distances in the profile E from 1 to 13 and place them on similar numbered lines drawn from the miter line in plan, measuring in every case from the line G^1 F^2, resulting in the intersections shown from 1 to 13 in the oblique elevation, from which points draw lines indefinitely parallel to 12 H^1, as shown. Take a tracing of the profile E, with the various intersections on same, and place it at right angles to 12 H^1, as shown by E^2, from which, at right angles to 12 H^1, draw lines intersecting those previously drawn. Trace a line through points thus obtained, when J will be the true profile of the raking trough. Knowing this, the pattern can now be obtained.

At pleasure draw the perpendicular M N. Draw also M N in Fig. 128, upon which place the stretchout of the profile J in Fig. 126, being careful to measure each and every space separately, as they are all unequal. From these divisions in Fig. 128, perpendicular to M N, draw lines shown. Measuring from the line M N in Fig. 126, take the various lengths to the various points in the miter line T and place them on corresponding lines in Fig. 128, measuring from the line M N. A line traced through points thus obtained is shown by A B. Then will 1 A B 13 be the miter pattern for the lower corner of the raking trough, shown by B in Fig. 125, and A B C D in Fig. 128, the miter pattern for the upper inside corner shown by C in Fig. 125. The horizontal troughs are to be formed after the profile E in Fig. 126, while the raking trough is formed after the profile J in the oblique elevation.

BEST MATERIAL FOR LINING GUTTER

It is the consensus of opinion that the best material for gutter lining is in the order named: soft copper, lead, tin and galvanized iron. Zinc is but little used

It is agreed that copper if properly laid to allow for expansion and contraction is the most durable material. The objection to lead is that while the metal

itself will last, it creeps when expanding and contracting, and this moving of the metal causes buckles which eventually crack; and the metal tears very easily. Copper is most always specified on high-grade jobs. For ordinary jobs a good tin plate, if carefully applied, will make a substantial gutter.

It must be remembered that a roof receives harder usage than any other part of a structure, especially the gutter—in summer the terrific heat of the sun and then a cool night, with perhaps a shower that is virtually a deluge; in winter extreme cold, snow, ice and sleet; storms that would pierce armor plate. Is it to be wondered that the material succumbs to the strain? If we buy a pair of the best shoes and wear them continually over rough pavement, through mud, snow or water, we expect that very shortly we must discard them; so why look for the impossible and demand that gutter linings last forever? Realize the aforesaid and when you line a gutter do it in the best known manner and give a reasonable guarantee and when the inevitable occurs let the house owner admit that his shoes are worn out and need repairing or replacing—that is, his gutter lining does.

LINING A LARGE GUTTER WITH COPPER—I

It is suggested that 20 ounces cold rolled copper be used to line a gutter like Fig. 129 so as to allow for expansion and contraction. It should not be calked direct to stone coping but as indicated. The lining should be laid as shown in the illustration, Fig. 129, to allow for expansion and contraction. The entire lining is free to work with this method. First a ledge indicated by *a* should be calked into the stone coping, having an outward bent flange at the top, to which the gutter lining is hooked as shown at *b*. The lining is bent in a manner as shown, with a lock attached at *c*, which goes under the tiling. This lock is fastened to the sheathing by means of cleats indicated by d and fastened or nailed at e.

In lining the gutter use sheets 72 x 36 inches wide, as the gutter is some 5 feet wide, tinning the edges of the cross seams 1½ inches on both sides and thoroughly sweating the joint with half-and-half solder, using 8 or 10 pounds soldering coppers and rosin as a flux.

At the highest points of the gutter expansion joints should be used as indicated in the illustration, in which A A shows the wood or concrete base over which the lining is laid. At the highest point of the gutter, instead of continuing the lining, a space of about ½ inch is provided as indicated by f and two heads soldered to the lining as indicated by B, with outward flanges as shown. Over these two flanges the cap C is slipped. This allows the metal to expand and contract.

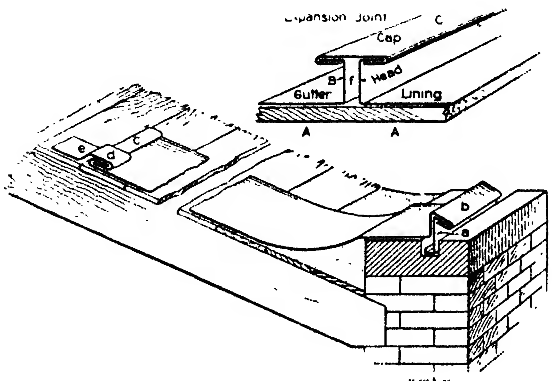


Fig. 129.—Allowing for Expansion in a Gutter

Thus by having expansion joints at the highest points of the gutter and the front edge hooked at b and cleated at d the entire lining has not a single nail in it and is free to expand or contract. The front ledge at b also prevents any water from running over the front edge of the coping, which is an annoyance in winter weather when the sun thaws the ice on the coping, which drops and freezes below in the shade.

LINING GUTTERS WITH COPPER—II

The following method is suggested for a gutter 75 feet long and of a width that takes 84 inches of copper. Under no consideration should the copper lining be nailed to the sheathing. When the walls at the side and two ends, shown by A in Fig. 130, are carried up as far as D, build in a cap flashing as there shown. The carpenter should then line out the gutter or valley with smooth sheathing warranted not to shrink, as shown by B and C, being careful to have a good pitch toward the leaders. The copper lining E is then put in position, slipping one end under the cap flashing D, and the other on the roof and have the slates so laid as to cover the copper about 6 inches. The copper to be fastened here by cleats as shown by G and H, and use copper 36 inches wide so as to have as few seams as possible. Where the cross seams occur the sheets should be thoroughly tinned 2 inches wide on both sides and a lock

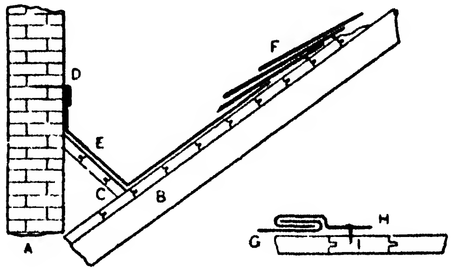


Fig. 130

placed thereon and fastened with cleats, as shown in the illustration, where G represents the sheets fastened by the cleat H, and nailed to the sheathing at I. In no case should the sheet be nailed directly to the wood lining, because the expansion and contraction of the metal would cause the copper to tear out at the nail. By using cleats the copper has a chance to expand with the heat of the sun and contract with the cold, the portions under the cap flashing and slate being entirely free. When the locked seams are thoroughly closed with the mallet use heavy coppers and thoroughly soak the seams with half and half solder. raising the cap flashing slightly to allow the soldering of the upright seam. Then lay a smooth board about 6 × 12 inches over the cap flashing and dress down well with the mallet.

REPAIRING BURST SEAMS

Thoroughly soak the seams with solder then over the seams solder a strip of copper which has been tinned, and of course where the edges of this strip is soldered to gutter tin that part of gutter then thoroughly sweat the solder in, going over two or three times and on the upright part of gutter reinforce the soldering by placing heavy stitches of solder close together.

LEADERS, GUTTER LINING AND COPPER ROOFING ON CONCRETE BASE

In the following illustrations are shown the methods employed in laying the copper gutters and roofing on a job in New York City. In Fig. 131 is shown the section and elevation of the gutter and leader and in Fig. 132 the plan of the soffit. It will be seen that the entire framing is of iron, with the brackets of wrought iron.

In Fig. 131 A is a sectional view, in which the arch D is of enameled brick, as shown in the view of the soffit in Fig. 132 by D^1. Over this arch in A in Fig. 131 is concrete D E, given the required surface pitch to the outlets. On the concrete is the gutter lining, this locking into the angle iron B. The roofing connects to the gutter by means of the mold C.

In the elevation F shows the leader head placed under the outlet tube of the gutter at V, the leader head F being connected to the lower head J by means of the gooseneck H. The main leader head J is then connected to the leader L,

which is held in position by the cast iron fasteners N, secured in turn to the stonework P by means of expansion bolts. The leader projects from the wall the distance indicated by N^1 on the plan Fig. 132, while F^1 and J^1 represent respectively

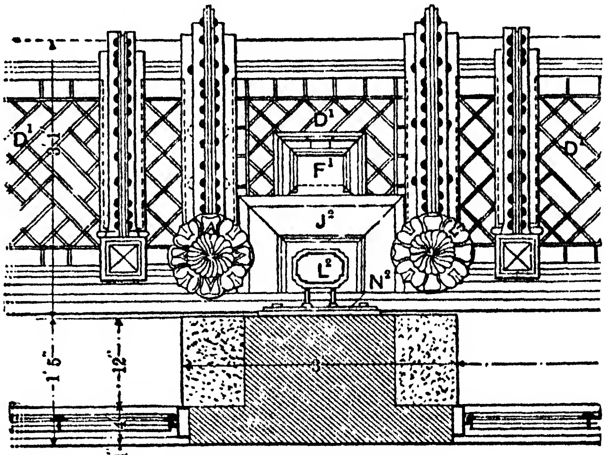


Fig. 132—Plan of Soffit

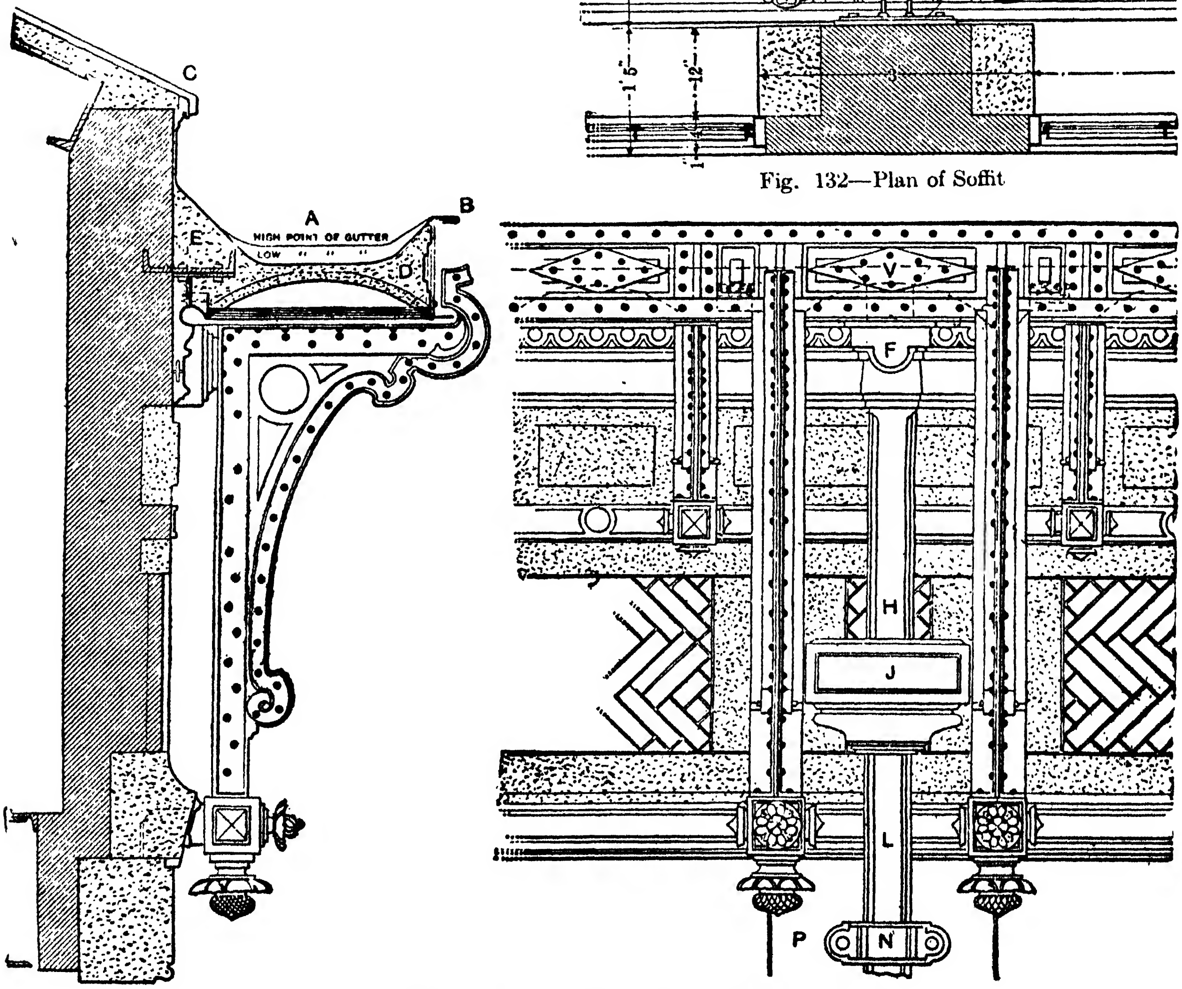


Fig. 131 —Section and Elevation of the Gutter and Leader

the soffits of the heads shown in Fig. 131 by F and J. The amount of the compound curve in the gooseneck H is indicated in Fig. 132 from F^1 to L^1.

The method used in laying the roofing and lining to overcome defects caused by expansion and contraction of the metal is shown in connection with Figs. 133 and 134. In Fig. 133 the construction of the gutter lining is indicated and also the method of securing the molding at the eave of the roof without nailing, but by the use of cleats. A is the brick wall, B the concrete gutter lining and C the concrete roof. E is the gutter lining, laid into the concrete gutter and locked into the angle iron at F and flashing up under the concrete roof at H. The angle iron at the front edge at F is secured to the ironwork as shown in Fig. 131.

Before the copper lining E is laid the cleats D and N are riveted to the gutter as shown and the rivet heads soaked with solder to avoid leaks, care being taken to obtain the correct location of the cleats so that when the molding J is placed on the eave of the roof the hem edged flange O will rest into the hook on the cleat, which is then closed with the mallet as at N. Note the drips formed on the molding at X and X. The upper flange of the molding J has a lock attached which is

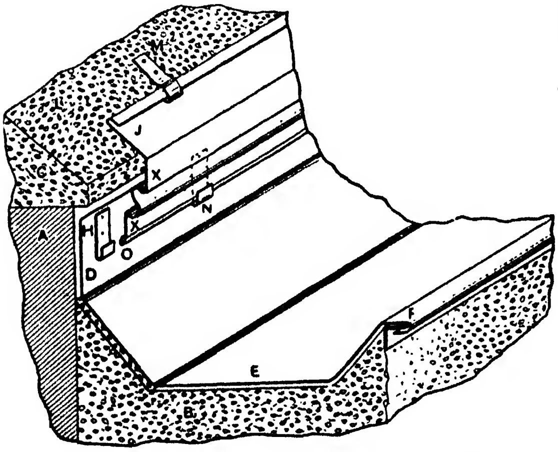


Fig. 133.—Construction of Copper Gutter

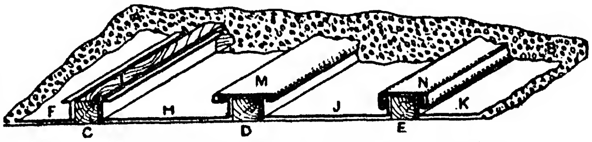


Fig. 134.—Construction of Copper Roofing

cleated to the roof L at M. Thus it will be seen that the entire lining and eave mold have no nails driven into the metal, thus allowing it to expand and contract freely. The cross seams in the gutter are first tinned, then edged, cleated and locked, thoroughly soaking the seam with solder, using rosin as a flux.

The roofing was constructed as indicated in Fig. 134, in which A B is the concrete roof. Wooden strips shown by C, D and E are nailed at given distances. Knowing this distance and the hight of the strip the copper sheets are bent on the brake in long lengths, tinning and edging the ends of the sheets, so that the cross seams can be locked. Assuming that this has been done, the sheets are laid in position as indicated by F, H J and K. The first operation is shown at L. The cap M is then slipped on and the locks are then closed and turned down in the position shown by N. In this way the sheets have room for expansion and contraction, the entire roof being free from nails excepting where the cleat is nailed

to the roof at the cross seams in F, H, J and K in the manner indicated in M of Fig. 133. At the ridge of the roof the sheets are double locked, as in standing seam roofing.

MAKING AND ERECTING THE CORNICE, GUTTERS, ETC., FOR A BUILDING AT A DISTANT POINT

There was erected a large building, for the joint use of a railroad as a terminal station and of the government as a custom house. It was made absolutely fireproof

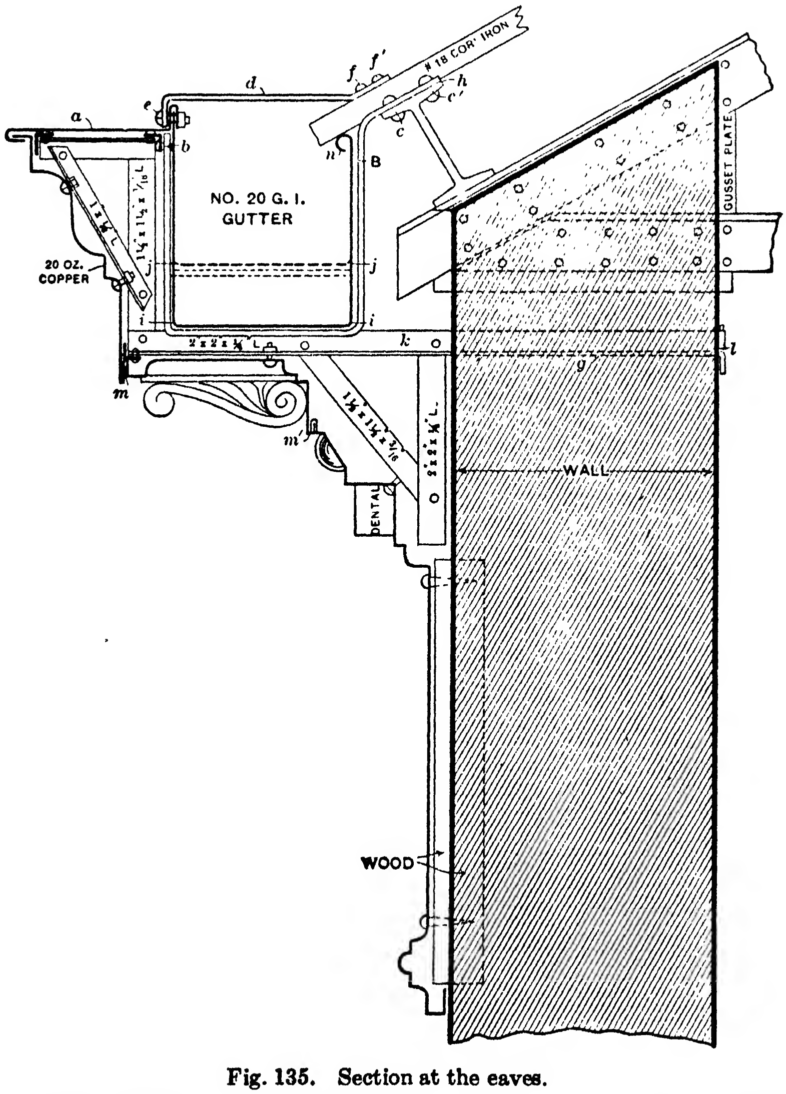


Fig. 135. Section at the eaves.

throughout, no combustible material being used. The main building was two stories in hight and about 130 feet square, with a 40-foot square court surrounded

by a promenade covered with special steel frame skylight construction. The train shed was the width of the main building plus 20-foot awning on each side and 760 feet long The roof of the train shed was constructed with three monitor ridges making two valley gutters, besides the eave gutters on the sides and awning gutters.

On the train shed there was approximately 2000 feet of awning gutter and something like 1500 feet each of eave and valley gutter, all made of No. 20 galvanized iron supported in wrought iron hangers and drained by wrought iron pipe conductors connected with the gutter by brass fittings. On the main building there was about 5,00 feet of main cornice of 20-ounce copper, 160 feet of

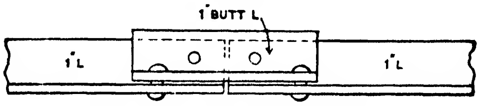


Fig. 137 —Angle Iron Joint

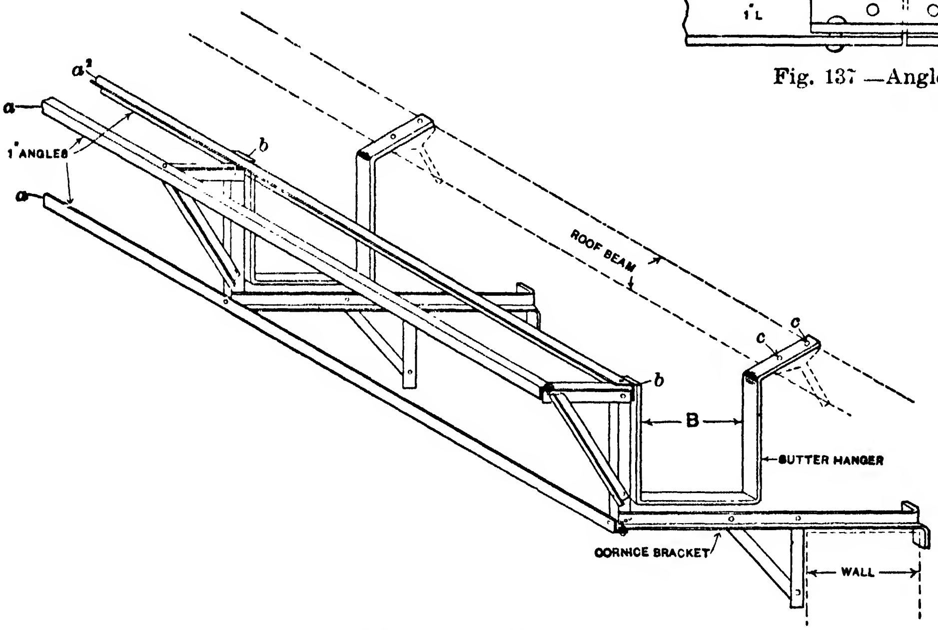


Fig. 136.—Wrought Iron Brackets and Hangers

copper court cornice, 1800 square feet of special skylight, 1000 feet of copper cresting, a number of large copper ventilators, two flagstaffs with fancy copper bases and several elaborate copper finials.

The metal work was done by a concern which made it all complete ready for erecting, so that nothing remained to be done at the building but to put up the sections of cornice, gutters, etc. A man was sent from the shop to do the work with local help. It will be seen from this that the planning and execution of the work in the shop must have been well-nigh perfect, as it all went up without the least hitch.

Fig. 135 shows the building construction at the eave, where the main cornice was attached, and a cross section of the main cornice and gutter; also a side view of the wrought iron supporting brackets and hangers. Fig. 136 is a detail showing the cornice brackets and gutter hangers alone. One-inch angles, a a^1 and a^2, run continuous, the brackets being spaced about 3 feet 6 inches apart. Fig. 137 shows how the joints were made in a a^1 and a^2. B is the gutter hanger, which was made of $\frac{3}{8} \times 1\frac{1}{2}$ inches bar iron. The hangers were riveted to angle a^2 at b and to the roof beams at c and c^1. The brackets were all alike, as the cornice was horizontal, but the gutter was made with a fall, each shed being about 20 feet long. Hangers B were therefore made of different depths, as indicated by the dotted lines, Fig. 135, the width, of course, remaining the same.

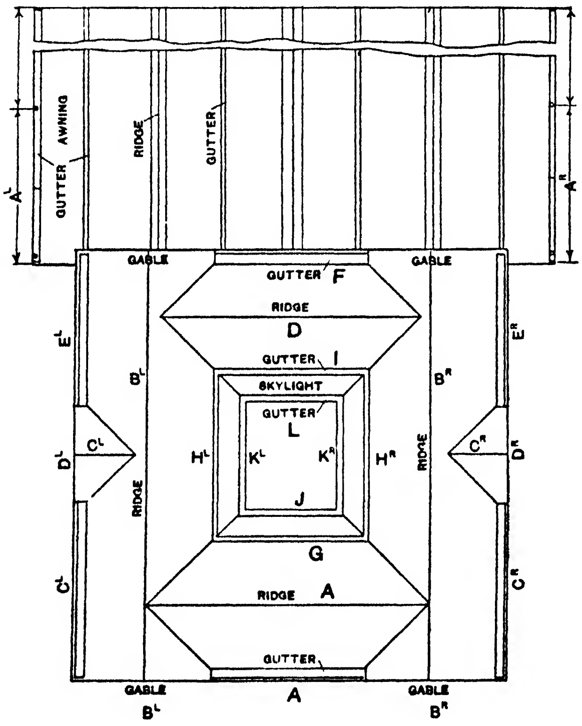


Fig. 140.—Plan of Skylight, Gutters, etc.

The main cornice was about 3 feet high and had stamped modillions and egg-and-dart and dentil courses. The work was planned so that the brackets were built in the wall by the masons. Next the gutter hangers were put in place and riveted, next the cornice then the gutter, and lastly the copper connecting piece, a, Fig. 135.

It will thus be seen that both cornice and gutter were accessible on both sides, which allowed of riveting the seams when being put up. After a was put on, dogs, d, made of $\frac{1}{8} \times 1\frac{1}{2}$ inches galvanized strap iron, were riveted to the standing edge e through a and the gutter and to the No. 18 corrugated iron roofing by two rivets at f and f^1. No expansion joints were made in the gutter, as it lay loosely in the hangers and was not sufficiently attached to anything to prevent free expansion and contraction.

The method of laying out the gutter was as follows: An elevation of a line of gutter was made to a $1\frac{1}{2}$ inch scale horizontally, as indicated in Fig. 138, showing the highest points, a and a^1, and the lowest point, b. Horizontal line, j j, Fig.

139, was then drawn to represent the highest point in the bottom of the gutter From b, Fig. 138, a line was dropped across j j, Fig. 139, and k established 3 inches below it, which was the actual fall of the gutter, and lines i k and k i drawn, showing the slope. Seams c, d, e, f and g, Fig. 138, and centers of hangers, 1, 2, 3,

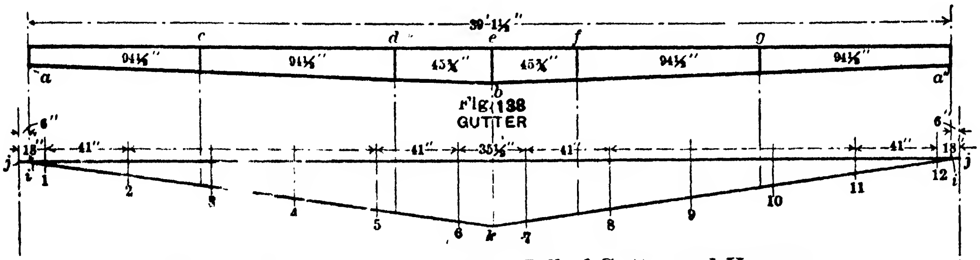


Fig. 139.—Spacing of Hangers and Fall of Gutter and Hangers

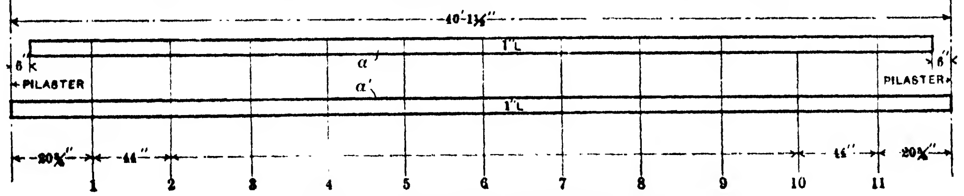


Fig. 141.—Cornice Bracket Spacing

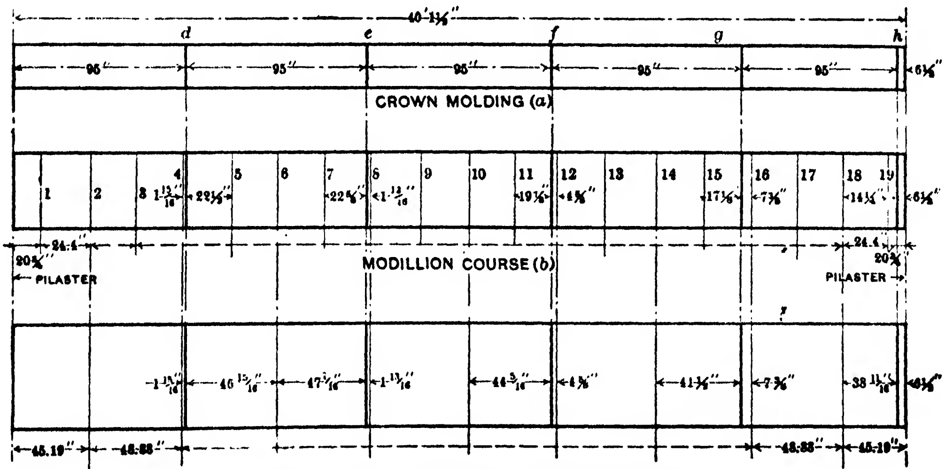


Fig. 142.—E & D, Dentil & Frieze Course (c)

etc., Fig. 139, was then spaced exactly to scale horizontally and lines drawn from them across j j and i k i, Fig. 139, as shown. The construction of the gutter and hangers above j j did not vary, see Fig. 135.

Center lines, 1, 2, 3, etc., being spaced horizontally exactly to scale, and j j and k being spaced vertically full size, the difference in the length of 1, 2, 3, etc.,

between lines j j and i k i was the actual difference to be made in the drop of the different hangers, and the difference in length of lines c, d, e, f and g between these lines was the difference in the ends of the 8 feet and shorter lengths of gutter.

All the hangers were numbered in consecutive order, and to show where the numbers belonged a small plan of the building was made, as indicated in Fig. 140, and the different stretches of main cornice and gutter lettered A, B, C, D, etc., thereon. A separate layout was made of each line of gutter, as in Figs. 138 and 139, which represent line A, Fig. 140. The gutter was got out by these layouts and each piece marked accordingly. The work was put together in the shop in 16-foot lengths, and strictly in accordance with the layouts.

As angles a, a^1 and a^2, Fig. 136, run continuously, and the lines of cornice vary in length somewhat, which varied the spacing of the brackets, a layout of each line of bracketing and cornice was made, showing the spacing and locating the rivet holes to be punched in angles a, a^1 and a^2. The layout is indicated in Fig. 141, which represents line of cornice A, Fig. 140.

Lines 1, 2, 3, etc., Fig. 141, represent the center of rivet holes in brackets through which angles a, a^1 and a^2 are riveted. Wood pieces were built in the wall, to which the lower part of the cornice could be secured by brass screws, and when the walls were completed up to the point g, Fig. 135, the brackets were placed in position and angles a, a^1 and a^2 riveted thereto—which took care of the spacing of the brackets—after which the wall was continued up and the roof structure placed thereon. The holes in beam h for receiving the gutter hanger rivets were punched by the sheet metal man with a heavy screw punch. The holes in angle a^2 and gutter hanger, at b, were, of course, punched in the shop. The 2-inch bracket angle k was made long enough to extend through the wall about 2 inches and had its inner end split and the flanges turned as indicated at l, which firmly secured it against being pulled out by the weight of the cornice and gutter, the weight having that tendency.

Fig. 135 shows seams in the cornice at the points m and m^1, which divided it into three sections of courses and facilitated the work of assembling. A layout of each course was made as indicated in Fig. 142. Course (a) represents the crown molding section; course (b) the soffit section, and (c) the egg-and-dart, dentil and frieze section. Ornaments were placed on the frieze under every alternate modillion. The vertical lines designated by letters indicate the seams in the cornice, and those designated by figures at course (b) the center of modillions and those at course (c) the center of ornaments.

It was, of course, necessary to carefully develop and figure all these layouts before any actual work was done in the shop. After all the layouts were made they were traced and blue printed and all the work in the shop and at the building was done from the same drawings and data. A complete copy of all data was sent to the builders. Thus every one connected with the work thoroughly understood and was governed by the same plans. All numbering and lettering on the gutter hangers and other wrought iron work was done by means of steel die stencils, which stamped the number into the metal. This was necessary, as the work was painted in the shop and again at the building before being put up, and any marking that depended upon color was therefore useless.

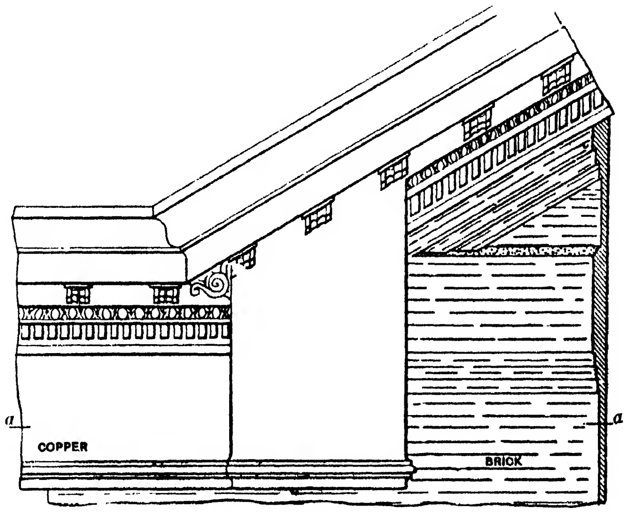


Fig. 143. Level and Gable Cornice Miter.

Fig. 143 shows the junction of the main level cornice with the main gable cornice on the front of the building, and it will be seen that the gable modillions, dentils and egg-and-dart molding, as well as the cornice, were raked. Fig. 144 is a section on *a-a* of Fig. 143 looking upward. The main gable cornice is the same as the main level cornice, except that the frieze and foot molding has been left off; the brickwork of the gables between pilasters being corbeled out in such a manner as to take the place of the frieze, this junction between level and gable cornices being novel. The gable cornice was laid out in the same manner as the level cornice.

Fig. 145 is a cross section through the gable cornice showing the junction with the corrugated iron roofing, and the method of securing the wrought iron brackets. It will be seen that the roof beams *a* overhang the wall and are faced on the ends with a channel bar *b* the same depth of the beams. The top horizontal angle *c* of the cornice brackets was made longer than for the level cornice and riveted to the top flange of the channel. The front vertical angle *d* of the brackets is secured to the bottom flange of the channel by a short piece of angle *e* riveted to both as shown. The 2-inch bracket angle *f*, instead of extending through the wall as for the level cornice, was cut off so as to project into the wall about 3 inches, and holes were chiseled in the brickwork after it was built to

receive the ends of the angles. Continuous 1-inch angles, a a^1, were used in the gable brackets, but a^2, Fig. 136, was omitted because of the connection to the flange of the channel bar.

The cornice moldings were gotten out in the usual manner, except as to a few points. Fig. 142, shows the spacing of the modillions and frieze ornaments as related to the seams in the cornice. Therefore, in getting out the 8-inch sheets or sections of modillion and frieze courses, after the laps were allowed, the distance from the seams to the nearest modillion or ornament was measured off and two prick marks made side by side in an imaginary line across the cornice indicating the center of modillion or ornament. In the modillion courses these prick

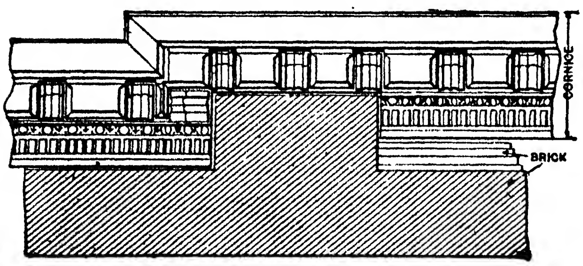


Fig. 144. Soffit Plan of Cornice.

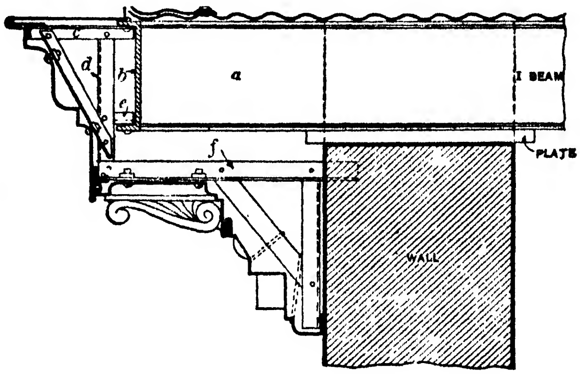


Fig. 145. Section of Gable Cornice.

marks were made at the point *a*, Fig. 146, and when the sheet was cut and pricked ready for bending, it looked like Fig. 147, the prick marks *b* showing the center of modillions.

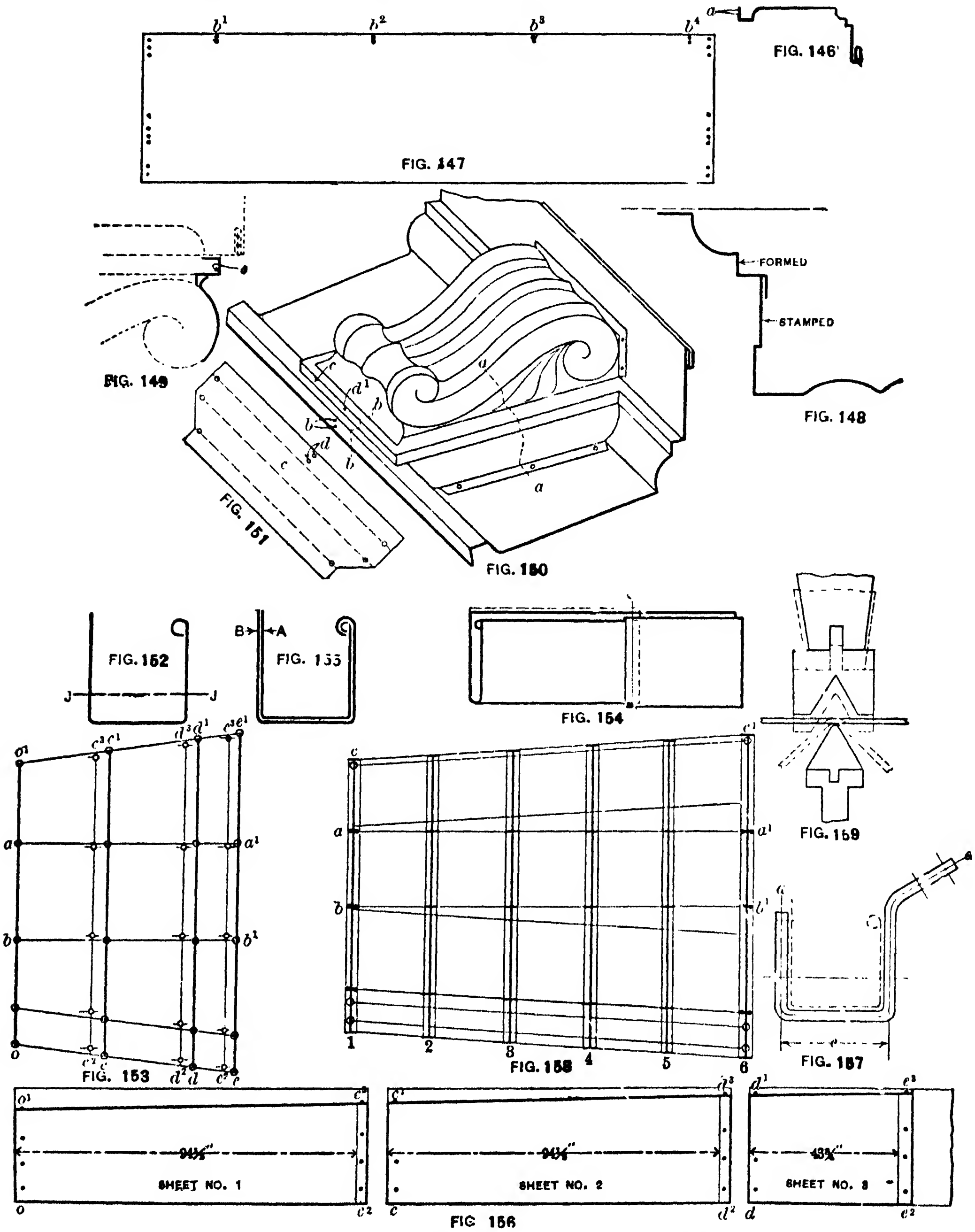
The face and sides of the modillions were stamped, but the bed moldings were made of plain crimped copper (all the copperwork was crimped) and connected to the stamped portion of the modillion in the usual manner, as indicated in Figs. 148 and 149, which shows a section on *a-a* and *b-b*, respectively, of Fig. 150, the latter being a perspective view of a modillion in place on the cornice. Fig. 151 is a pattern of *c*, Figs. 149 and 150. The prick mark *d*, Fig. 151, was made in the pattern and pricked lightly into each piece, so that when the modillion was formed ready to place on the cornice, prick mark *d* showed as indicated at d^1, Fig. 150. This saved the time and possible inaccuracy incident to measuring or guessing the centers of the modillions when attaching them to the cornice. It requires much less time and is far more accurate to prick the modillion courses and moldings than to do the measuring necessary to spacing after the cornice and modillions

are completed. Proper allowance was, of course, made on each end of the crown molding course for the miters at the junction between the level and the gable cornices.

Figs. 138 and 139 represent the layout of one line of the main cornice gutter. After this layout was completed the work of getting out the gutter and hangers was proceeded with as follows: For convenience the profile of the gutter was traced from the full size detail represented by Fig. 135, as indicated by Fig. 152. The solid line, of course, showing the lowest point of the gutter and the dotted line J J the highest point. Next, lines a-a^1, b-b^1, Fig. 153, were drawn parallel to each other and spaced the width of the gutter apart; then the line o o^1 was drawn perpendicularly across these two lines; then lines c c^1, d d^1, e e^1, were drawn parallel to o o^1 and represented the seams in the gutter. These seams lines were spaced exactly to 1½-in. scale from o o^1. Then the full size stretchout of the shallowest part of the gutter was laid out on o o^1, and the stretchout of the deepest point of the gutter on e e^1 and the lines o e and o^1 e^1 drawn, cutting the intermediate seam lines which established the stretchout of the ends of the three different pieces of gutter.

As the material was of No. 20 gauge, it was necessary to make proper allowance in the stretchouts, so that the end of one piece would lie in the end of the next piece. Fig. 154 is a side view showing a lap joint in the gutter, and Fig. 155 is a section on a a of Fig. 154. It will be seen that the stretchout of inside end A, Fig. 155, must contain less material than outside end B. In Fig. 153 c c^1 is the stretchout of B, and c^2 c^3 that of A. It will be seen that allowance is made in the bottom and in both sides of the gutter. This seam allowance was also made in all lap seams as shown. Having thus obtained the stretchouts, the piece of paper on which they were laid off was laid on the ends of the sheets and the points pricked into the iron. Fig. 156 represents the three sheets of iron of which one shed was made. The paper stretchout sheet, Fig. 153, was laid on the left hand end of sheet No. 1, Fig. 156, with stretchout o o^1 about ¼ inch back from the end of the sheet, and the points pricked through; then stretchout c^2 c^3 was pricked on the right hand end of the sheet in a similar manner; then stretchout c c^1 was transferred to the left end of sheet No. 2, and stretchout d^2 d^3 pricked on the right hand end; then stretchout d d^1 was transferred to the left end of sheet No. 3, and stretchout e^2 e^3 on the right hand end. Stretchout e e^1 was of course used on the left hand end of the adjoining sheet of the next water shed, and the process continued inversely.

The lengths of the sheets Nos. 1, 2, 3 was, of course, taken from the layout, Fig. 138. The dimensions shown being net the laps are allowed in addition to



Method of Preparing Cornice Moldings and Cornice Gutter

same. After the sheets were thus pricked marked, they were cut to the proper width, which prepared them for the 8-foot upright power brake.

In getting out the wrought iron gutter hangers a full size detail of the hanger was taken from the full size cornice and gutter detail, represented by Fig. 135, as indicated in Fig. 157. Owing to the thickness of the hanger it was necessary to draw the center line *a a*, from which to take the stretchout. The stretchout of the different hangers in a water shed was obtained as follows:

Referring to Fig. 158, *a a′* and *b b′* were drawn parallel to each other and spaced a distance apart equal to *c*, in Fig. 157. Line 1, Fig. 158, was then drawn perpendicularly across *a a′* and *b b′*, and the stretchout of the hanger, No. 1, Fig. 139, laid off thereon, as indicated. Lines 2, 3, 4, 5 and 6 were then drawn, being spaced to a 1½-in. scale, in accordance with the layout, Fig. 139. The stretchout of the hanger No. 6 Fig. 139, was then laid off in line 6, Fig. 158, and lines *c c′* and 1, 6, Fig. 158, drawn, cutting the intermediate lines. The holes and bends in the hangers are then taken from the detail represented by Fig. 157, and spaced on stretchout lines 1 and 6, Fig. 158, as indicated. Lines were then drawn connecting corresponding points in No. 1 and No. 6, which located the holes and bends in 2, 3, 4 and 5. These lines were then exact stretchouts through centers of hangers. Lines were then drawn on each side of these center lines, spaced half the width of the hanger therefrom, and the stretchout sheet, represented by Fig. 158, was then laid on the bar iron and the cuts, holes and bends center-punched through the paper into the material, and each hanger immediately die-stencil marked, after which the material was cut and punched.

The hangers were bent up cold with special dies in a 5-foot upright power brake, as indicated in Fig. 159, the bends being rounded so as not to break or unduly strain the fiber of the metal. It will be seen at a glance that bending in a brake in this manner saved most of the time, which would have been consumed in heating, and bending in a vise, or otherwise by hand, and was easier and quicker than using an ordinary brace bender.

Fig. 160 represents a cross section of the awning gutter, showing method of hanging, and Fig. 161 the train shed valley gutters, and Fig. 162 is a section of the court cornice and gutter, which receives the water from the special steel frame skylight. The inside edge of the court cornice gutter had a 5-8 inch lock edge turned on it, as indicated at *a*, and the finishing piece *b*, was locked to it and notched out to fit around the bottom of the skylight bars, as indicated; after *b* was secured by clips *c* the seam was closed down with a heavy mallet. Fig. 163 represents a cross section through one of the skylight bars and Fig. 164 shows how the glass was secured at the bottom to prevent sliding down.

The last three gutters, with their hangers, were planned and got out in the same manner that the main cornice gutter was, except that the bottom bend lines of the gutter, corresponding at *a a′* and *b b′*, Fig. 153, were not parallel, and similar

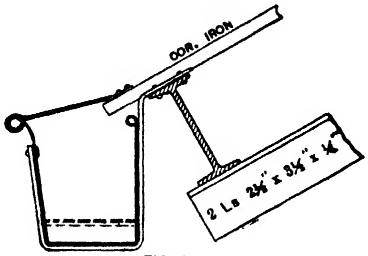


FIG. 160

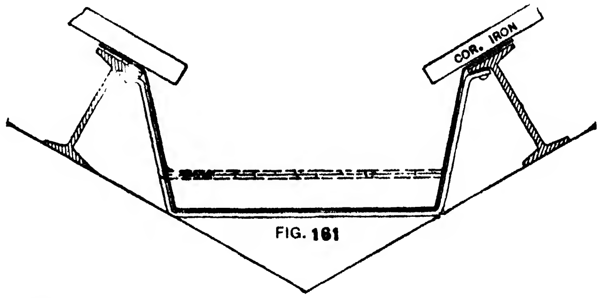


FIG. 161

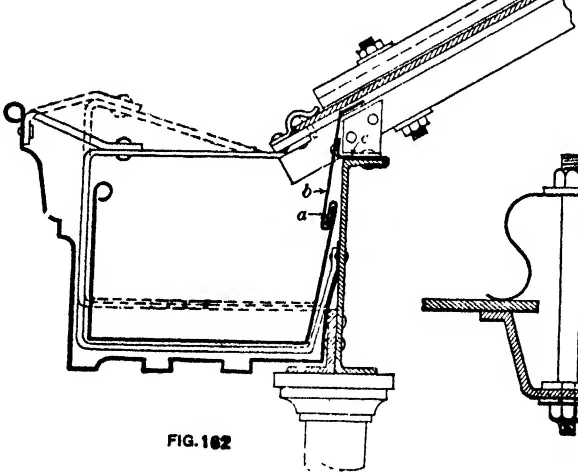


FIG. 162

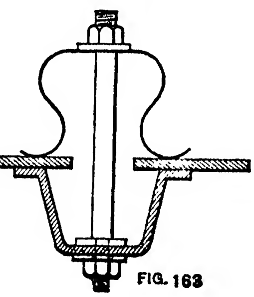


FIG. 163

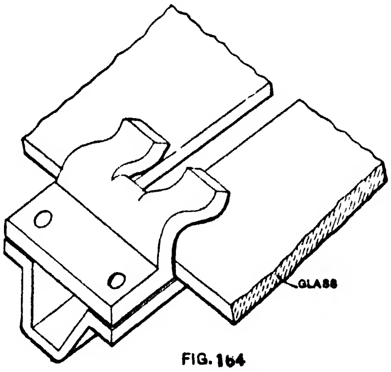


FIG. 164

Some of the Special Gutters and Details of Skylight Work

lines of the hangers, corresponding to *a a′* and *b b′*, Fig. 158, were also converging, as the bottoms as well as the sides of these gutters tapered.

In these gutters the distance *a b*, Fig. 153, was equal to width of bottom of gutter at highest point, and *a′ b′* equal to width at lowest point. In Fig. 158 *a b* was equal to the width of the bottom of the highest hanger and *a′ b′* equal to the bottom width of the lowest hanger. Otherwise the entire process of laying out and getting out was similar to that above described.

EAVE FINISH FOR METAL ROOFS

Herewith is presented a number of methods for securing sheet metal roofs at the eaves. A very simple method is shown in Fig. 165, where the tin is bent

over the roof boards and nailed. This manner of securing the tin is very defective, as the underside of the roof boards are unprotected, and, unless the tin extends below the edge of the roof boards, capillary attraction will cause water to be drawn between the tin and the boards. In Fig. 166, the tin is bent down and out so as to form a drip, and while this form appears to be an improvement on the previous one, the underside of the roof boards being unprotected, there is a chance for either wind, fire or water to enter. In Fig. 167, is presented a method that finds favor with many tinners. A strip of galvanized iron is nailed along the eaves, and over this strip the tin is laid and locked over the edge. This does not form either a fire or wind proof finish, as the underside of roof boards are unprotected. In Fig. 168, the roof tin is so formed as to reach under the roof boards and cover them, and if the space between brick and roof boards is well filled with mortar or cement, a tight joint will result. As shown in Fig. 169, strips of tin are so formed as to extend under the roof boards, and at the same time project sufficiently to allow the roof tin to be hooked on, thus protecting the under side of the roof boards and forming a drip. In Fig. 170 the roof tin is so formed as to produce a drip, the tin being secured to the roof boards by nailing. In Fig. 171 the roof

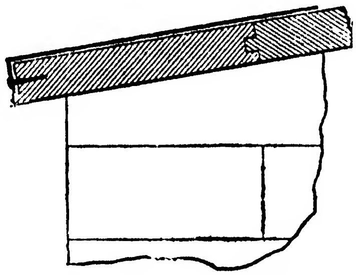


Fig. 165.—Single Bend in Tin

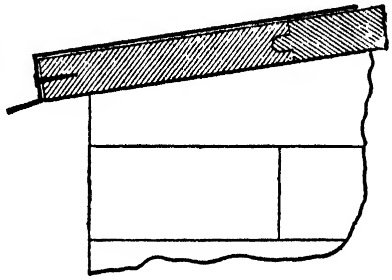


Fig. 166.—Double Bend in Tin

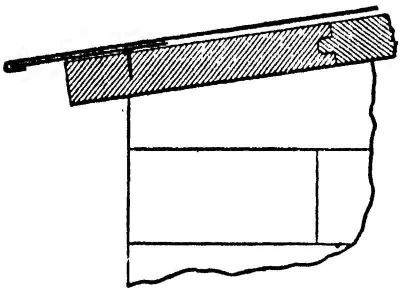


Fig. 167.—Sheet Iron Nailed to Roof

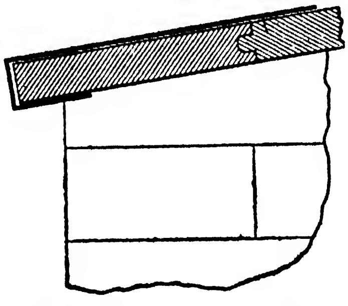


Fig. 168.—Tin Bent Under Edge of Roof

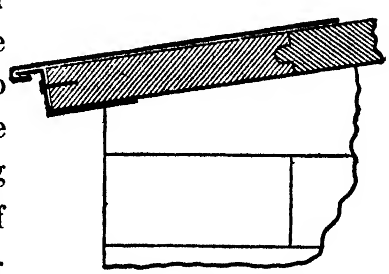


Fig. 169.—Drip Formed by Bent Strips of Tin

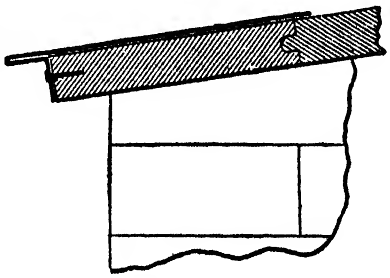


Fig. 170.—Drip Formed in Roof Tin

tin is bent in such a manner as to form a drip, and at the same time extend under the lower part of the roof boards. Strips of tin can be formed, as shown in Fig. 172, and placed under the eaves, being secured by nailing. The roof tin is then to be hooked on and double seamed over. It is to be understood that these methods are applicable to the linings of box gutters.

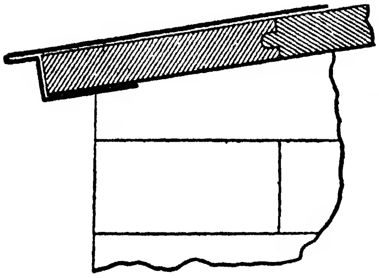


Fig. 171.—Tin Bent Under Roof Board

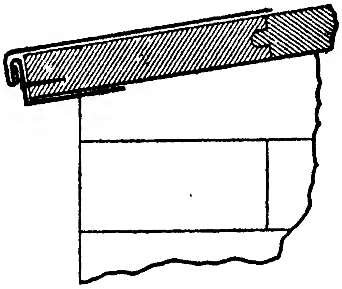


Fig. 172.—Double Seam at Eaves

A ROOFING NOTCHER

It consists of a board 2 inches thick and 10 × 14 in size. At one end of this is fastened securely a piece of tool steel, one edge fitted as a cutting edge, and attached to one end, by means of a bolt with a countersunk head, is the other blade of the shears, which terminates in a short handle. The upper blade is so bent that a very slight movement opens the jaws of the shears sufficiently to insert a sheet of roofing tin. The upper blade is connected with an upright support by means of a spring which keeps the shears continually open. Guide plates are screwed to the board, as shown, so that the sheet of tin to be notched can be pushed up against the guide plates, a corner extending beyond the lower blade of the shears. The spring holding the blade of the shears open, the upper blade can be brought down and a corner of the sheet neatly and correctly cut off, as is required for flat seam roofing laid one sheet at a time. It is a simple matter to attach a rope to the upper blade of the shears so that it can be drawn down by a motion of the foot in a stirrup placed in the lower end of the rope, leaving both hands free to handle the roofing sheets. If the blades are made of heavy and good material, fastened securely together, several sheets may be notched at the same time. It is found in practice

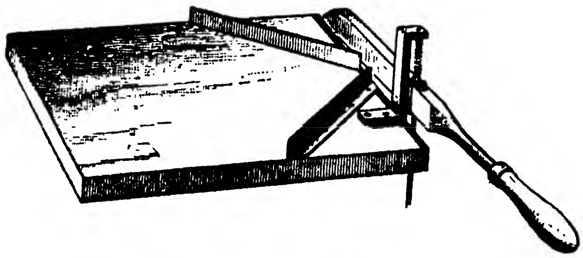


Fig. 173.—A Roofing Notcher

that a man can notch the roofing sheets more quickly by this means than can be done by either hand or bench shears, and certainly much more accurately.

A DEVICE TO ROSIN ROOF SEAMS

This apparatus, as shown by the illustration Fig. 174, is used to apply the rosin on seams of roofs by filling it with powdered rosin and placing the end with the small hole on the seam and inserting a hot soldering copper in the rosin which then melts and flows through the small hole and on the seam as the device is drawn along.

It is made funnel shape about 4 inches in diameter at the large end, 3-16 inch at the small end and 6 inches long; to this is attached a handle 2 feet long of $1\frac{1}{4}$-inch band iron.

Fig. 174.—Rosining Roof Seams

STORING LADDERS AND SCAFFOLDS

Herewith is presented a method of storing ladders and scaffolds in length from 20 to 28 feet. As the space in the shop was limited, a novel idea came to mind, namely, to make the necessary hooks, bands and rollers, and store the ladders or scaffolds underneath the floor beams, or, in other words, hang them beneath the ceiling. The illustrations herewith presented will show how this was accomplished. In Fig. 175 is shown the front and sectional views of a ladder hanger, the ladder being placed at right angles to the beams. A, in the sectional view in Fig. 175, indicates the wooden beam; B, the sectional view of the 3-16 × $1\frac{1}{4}$-inch band iron bracket, which is screwed against the beam A as shown; D and D show the front elevation of the brackets, screwed to the beam C. The width of the ladder J being known, the brackets D and D are spaced accordingly, so as to allow the ladder or scaffold play room to slide in or out, as shown. E represents a $\frac{1}{2}$-inch iron rod placed through the brackets D and D as shown.

By boring or drilling two $\frac{1}{8}$-inch holes at each end of the rod E, two pins, H and H, are placed in it to prevent the rod from slipping out of the brackets when putting up the ladders. Before placing the rod E through the brackets a 5-8-inch gas pipe (inside measure) is slipped over it, as shown at F, and forms a roller, which lightens the work of sliding the ladders in place. L, Fig. 175, indicates

a stationary hook made of 3-16 × 1¼-inch of band iron, twisted half way around, as shown, and screwed fast to the wooden beam. M is a twisted hook fastened to the beam with one long wood screw, which acts as a pivot, and allows the hook to be swung outward when desired. To hang a long ladder, say 25 feet in length, the brackets D and D and hooks M and L would be placed about 20 feet apart. To slide the ladder between the ceiling with hardly any trouble whatever proceed as follows: Raise one end of the ladder up from the floor until it rests upon the pipe F Fig. 175, then raise the other end of the ladder, being careful always to

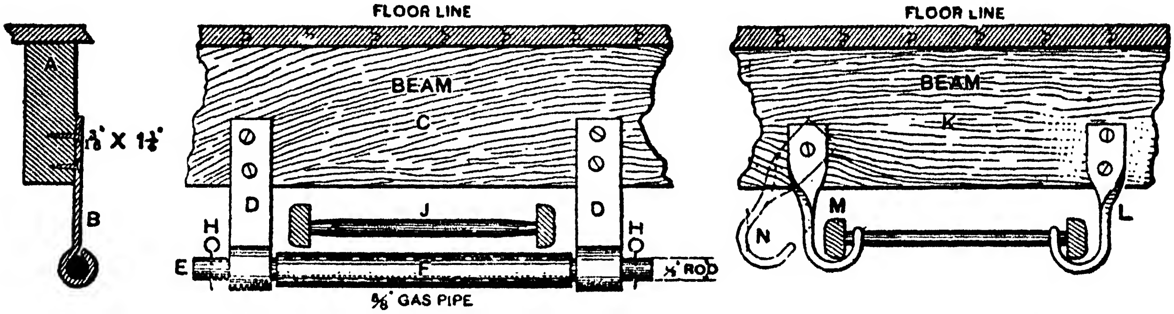


Fig. 175.—Front and Sectional Views of a Ladder Hanger, Hung Crosswise to the Beams

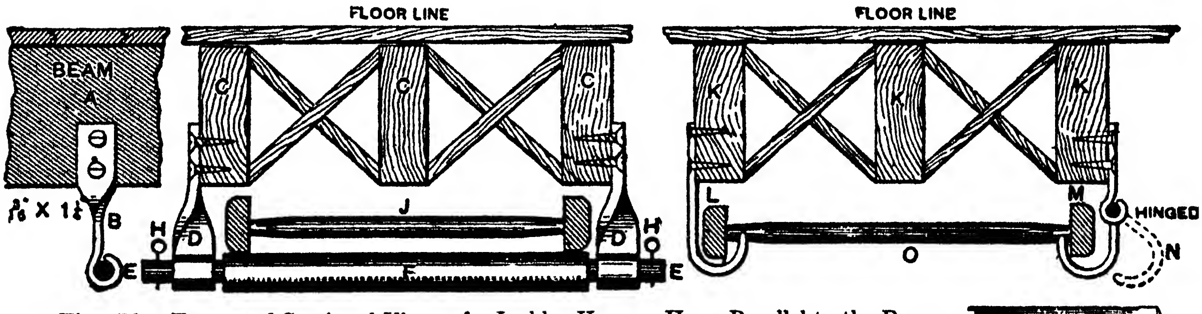


Fig. 176 —Front and Sectional Views of a Ladder Hanger, Hung Parallel to the Beams

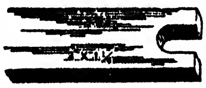


Fig. 177.—Spruce Lifter

press toward the pipe F, as the tendency is to slide out; now, holding it up at arms' length, obtain a spruce slat 1¼ × 3 inches in thickness and long enough to reach the ceiling, have a groove cut in one end of the slat, as shown in Fig. 177, and placing the groove under one of the rungs of the ladder, raise it slowly, always pressing toward the pipe F, until it sets in the stationary hook shown at L in Fig. 175; now press the hook N forward by means of a strip of wood to the position M, which secures the ladder.

When taking down the ladder or scaffold the same operations should be performed reversed. Fig. 176 shows the front and sectional views of a ladder

hanger, the ladder being hung parallel with the beams; whereas in Fig. 175 the ladder hung at right angles with the beams. The only change required in this case is that the brackets shown at D and D in Fig. 176 require twisting, as shown, and the hook shown at M in Fig. 176 must be hinged so as to allow it to work back and forth.

SUGGESTIONS FOR LAYING SLATE ROOFING

There was a time in the history of slate roofing when it was considered a definite trade, and guarded so jealously in its details that the slater did slate work only. When tin work was required, such as valleys, flashings, etc., the tinner was called on to execute it. During the last decade or more, however, all has been changed in this, as well as in work of other character, and there are now more tinners doing slate roofing than legitimate slaters, and we desire to say at the very outset that what follows is intended more especially for the benefit of the numerous roofers and tinners who have had no experience or opportunity to learn slate roofing, while at the same time it may interest and meet the approval of old slaters.

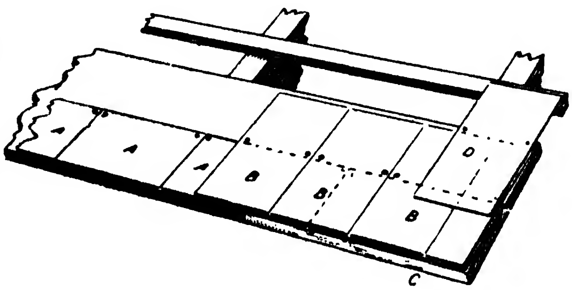


Fig. 178.—Method of Laying Slate at the Eaves

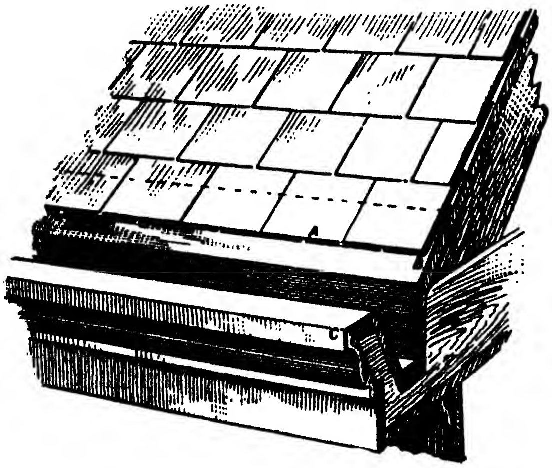


Fig. 179.—Lining a Cornice having a Gutter

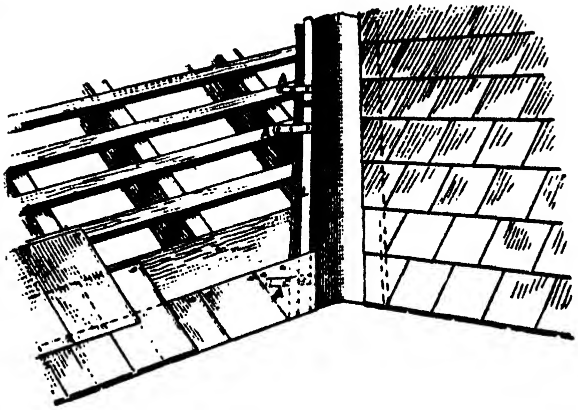


Fig. 180.—Showing a Valley in a Roof

The better sizes of slate are considered as varying from 10 × 20 to 12 × 24, the smaller size for dwellings and small buildings, the larger for factories and barns.

A good size for a medium roof and one easy to lay is 11×22, giving $9\frac{1}{2} \times 11$ exposed surface. However, in a great many localities a 2-inch lap on the third course is given instead of 3 inches, which would make the exposed surface 10×11. Of this we will speak later.

The object of using an even multiple of length by width is to be able to break joints evenly in length by the width when required. Slate of different lengths may be used on the same roof when necessary, if the width is the same, and the length equal throughout any one course. This is done by regulating the lap of the slate so that they all have a lap of 3 inches at the bottom over the nails driven to hold the second course below them.

The only exception to this is at the eave, where the bottom or eave course is laid lengthwise, as shown by A A, Fig. 178, from gable to gable. The next or second course covers the bottom course, edging with it at the eave, and lying lengthwise up the roof, but starting with a half width slate, bringing the joint, as shown at C, after which whole slate will break joints throughout the row, as shown by B B. The next or third course D is started with a full width slate, breaking joint over B B and lapping $1\frac{1}{2}$ inches over the top edge of the bottom eave slate, as shown. The next or fourth course is started with a half width slate. Continue alternating until the comb has been reached. Three inches are usually allowed for the third under lap, and slate quarrymen and dealers send enough pieces to the square to lay a full square allowing the lap referred to, yet in some localities where quality is sacrificed for price, a 2-inch lap only is given, making a saving of $\frac{1}{2}$ inch to each course of slate, apparently trifling, yet amounting to 30 square feet in two sides of such a roof as that shown in Fig. 181. The size of the roof being 20×14 feet 10 inches and the size of the slate used being 10×20 inches, the roof will require 21 courses, with 24 slates to the course, with 3-inch lap. With a 2-inch lap less than 20 courses will cover the same surface, a saving of 48 slates 9×10, equal to 4320 square inches, or 30 square feet, or approximately 5 per cent, a small gain for inferior workmanship.

The color of the slate to be used must be determined by the customer. Black is a color that will not fade and is very desirable. A good quality is found in the Bangor district in Pennsylvania. Unfading green, sea-green, purple, variegated and red are quarried in Vermont and north New York. Red slates are unfading, but they are too expensive to use except in working out such a design as that shown by Fig. 181, in which the red slates are shaded lighter than those supposed to be black or green. This design requires only 48 to either side of the roof.

A pleasing combination for figure or design work is made by using purple for the figure and unfading green for the body. Sea-green looks well when new, yet the liability to fade and form all manner of grotesque figures, renders it unreliable. Sea-green is the cheapest slate for roofing purposes, and the monotony or sameness may be broken, when it is used exclusively, by running courses of the slate with the corners cut, as at A and A in Fig. 181, alternating with slate having square corners. The soundness or quality of the slate may be determined by a slight tap of the hammer in laying. If a clear ringing sound is given out you can depend on their being perfect. If defective, black slate break lengthwise, green slate through their width.

Slate from the quarry must be in carload lots to get the best freight rate, and as it is rated at 600 pounds a square, 40 squares—12 tons—is a minimum carload. Unless one has contracts calling for more, as a start, this amount may be divided into 30 squares green and 10 squares of purple, size 11 × 22, which is not too large for a small building or too small for a larger one. It is good stock and can be realized on at any time. No matter, however, what size or color you prefer, do not order less than a carload, as local freight rates on slate are ruinous to profits.

Too much care can not be taken in lining a cornice having a gutter, as illustrated in Fig. 179. No matter what metal it may be lined with, galvanized iron, after copper, an important item is to have the back part of the gutter at B higher than the front C, the first course of slate to be laid 2 or 3 inches higher up the roof than a point level with the front as shown at A. This is to provide against an overflow into the building in case of freezing and snow thus forcing the overflow in front in case of an emergency, especially when the conductor pipe has become clogged. To prevent the latter, wire strainers should be placed in all outlets. All the metal of the roof gutter above the first row of slating nails is useless; nails, in short, should not be driven through the metal at all, as the expansion and contraction of the metal will work holes the larger, and if not high enough leakage will follow. Capillary attraction and nail holes have been the cause of hundreds of unexplained leakages.

A valley in the roof is shown by Fig. 180, one side of which has the slate laid complete, and has the eave course started on the left side showing the slate projecting over a common plastering lath "L," laid along the edge of the valley over the metal to give the valley course of slate the proper elevation at their butts. The lath is held in place by means of strips of galvanized iron nailed to them as

at A A. These strips are nailed back of the edge of the valley and not through the metal. The slate can project over the lath an inch and the lath be placed 5 inches from the center of the valley on each side, giving 4 inches of exposed valley on each side of the center. To get an even edge it is best to use chalk and line it.

For hip and comb finish it is good economy to use a ridge roll, as illustrated

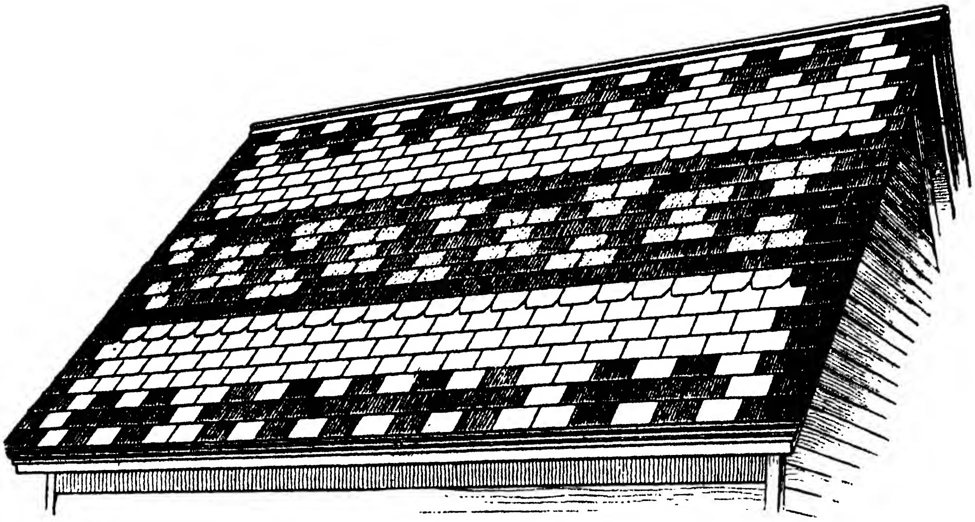


Fig. 181.—Roof Showing use of Slate of Various Colors, Forming what is known as the Double Maltese Cross Design

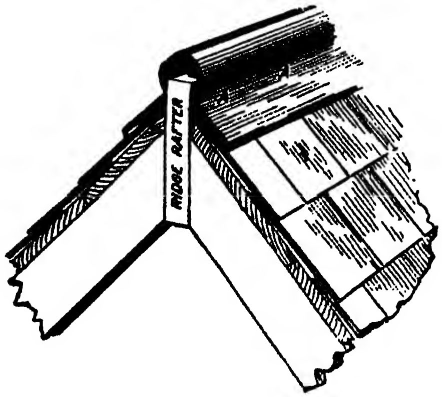


Fig. 182.—Hip and Comb Finish

Fig. 184.—A Slater's Ripper

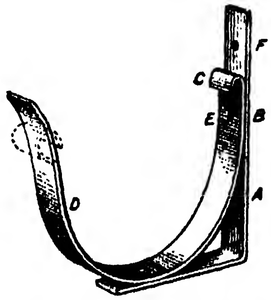


Fig. 183.—Style of Eaves Trough Hanger Recommended

in Fig. 182. The comb or ridge rafter should project above the roof sheathing an inch to allow the cap to be nailed to it, as shown at A and A, and also against which the slate may abut.

Flashing, chimneys, fire walls, skylights or places where the roof abuts against another building are proceeded with in the same way as in tin or shingle roofs, the slate being cut to the required size and shape.

The roof foundation may be either lath $\frac{7}{8} \times 3$ inches or 4 inches, or solid sheathing. If lath are used they will have to be spaced so that the top of the rows of slate will rest on the center of the lath, the bottom slate having a 3-inch lap over the top of the second course below, as shown by Fig. 178. If the size of the slate is 10×20, this will give an exposed area of 85 square inches to each slate, or measuring surface of $8\frac{1}{2} \times 10$.

Unless very cheap work is desired it is at all times advisable to use common sheathing, surfaced on one side, placing the rough side up; this, covered with slater's felt, will prevent sleet, snow or driving rain from being forced into the garret. Slate should not bind at the side edges, as it will prevent drainage between the slate and induce breakage by freezing in cold weather.

If laths are used upon which to lay the roof, the bottom or eave should be sheathed solid for at least three courses, to provide a solid base for the eave trough hangers, etc. A hanger free from the roof is undoubtedly preferable, and such is shown in Fig. 183, which can be made in the shop of hoop iron and of a gauge suitable for the purpose intended; that is, it does not require as heavy iron for a $3\frac{1}{2}$ inch hanger as for 6 or 7 inches. The band D is formed in the rolls after the hole E has been punched or drilled, after which the hook C is formed by turning the end down $\frac{1}{4}$ inch to receive the back edge of the trough. The front is slightly curved as shown; the strap is then riveted to the brace A, having two screw holes at B and F, which completes the shop work on it. In hanging the trough a brace is placed at each end of the roof, secured to the fascia board, or the end of the rafters, by means of wood screws; one "F" above the hook C and one engaging both the strip D and the bracket A at the holes E and B. The bracket at the outlet being lower than the one at opposite end provides for the pitch and a line stretched from the bottom of one to the other provides a gauge for the placing as many more in the intermediate as may be deemed necessary. The trough is laid in the bracket, using care to have its back edge the engage hook C, Fig. 183. When the strip D is formed over the bead in front, as shown by the dotted lines, the hook C and the formation over the bead will keep the trough in shape and position; its advantages are an unobstructed flow, strength, and the avoidance of nailing through the slate.

A set of slater's tools requires but small outlay, a handy blacksmith being able to make all required. However, a set bought from a dealer is generally better proportioned and the additional cost so slight that it is advisable to buy from the latter. A slater's hammer, a ripper, shown in Fig. 184, a stake and nail punch

are required. A home-made hammer can be made by welding a steel point to the blade of a hatchet, as at Fig. 185.

A steep roof requires scaffolding. The brackets may be made out of scrap pieces of wood to be found around a new building, as shown in Fig. 186. The

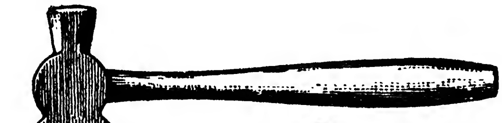


Fig. 185.—A Home Made Slater's Hammer

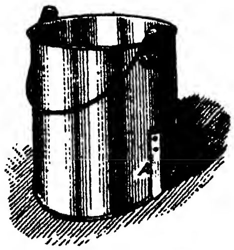


Fig. 189.—A Roof Paint Bucket

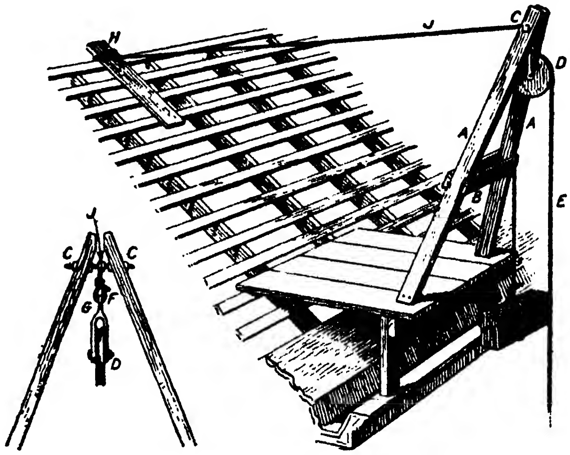


Fig. 187.—Details of one Form of Derrick used in Raising Slate to Roof

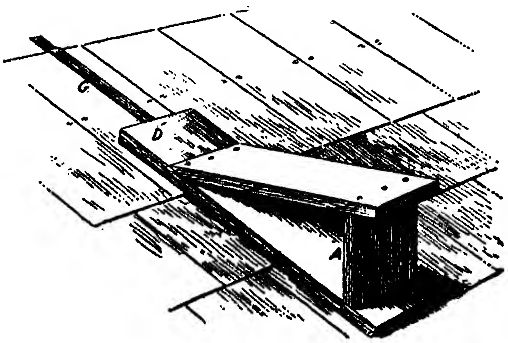


Fig. 186.—A Scaffold Bracket for Slaters' Use

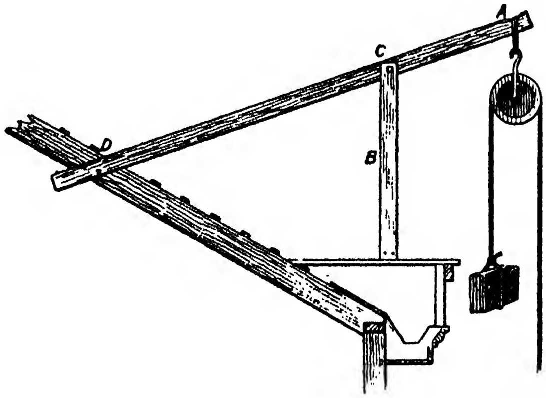


Fig. 188.—A Projecting Beam Derrick

pitch of the bracket is regulated to conform with the pitch of the roof by the length of the standard support A. The bottom board need not be longer than from 16 to 18 inches. A galvanized iron strip, G, is nailed on the under side of it at D, and is of a length to reach over the top of the last course of slate laid, approximately 18 inches; and to allow the front of the bracket to be down the roof far enough not to interfere with the lap of the next course of slate to be laid, the brackets are distributed across the roof, nailed to the sheathing by means of the galvanized strips, and common 10 or 12-inch sheathing boards are laid on top of them,

from which to work. Slates are laid upon the boards and stacks of slate are piled immediately above the brackets, and the number of brackets required for safety must be determined by the workmen. The slate is laid up the roof, over and regardless of the galvanized iron strip, and when the roof is completed the bracket is removed by placing one hand on the slate over the galvanized iron strip and bending the strip close up to the bottom of the slate, when it will break off, freeing the bracket.

A device for raising slate to the roof is shown by the derrick illustrated in Fig. 187. This derrick is made with 2×4 standards, A A, 7 feet long. Two boards, 1×4 inches, are nailed, one on each side of the standard near the center B, and of such a length as to spread the standards 3 feet at the bottom and 6 inches at the top. The top rod, ½ inch, will secure the standards firmly by using nuts and washers both inside and outside, which are drawn up tight, as shown at C C in the detail sketch at the left. The rope J with the loop F is tied around the rod and taken to the comb of the roof, where it is coiled around the board H, which is nailed and projects over the opposite side of the comb, as shown. The wheel D, or iron sheave as it is commonly called, shown at D in Fig. 187, is made after the style of a bicycle rim, but of iron, and about 1 foot in diameter. A bolt passes through it, to which a forked rod is attached, on the end of which is the hook G, which engages the loop F of the rope J. The rope E should be of a length that will allow both ends to touch the ground after passing over the wheel D. A small chain may, if desired, be attached to the end of the rope engaging the slate, which will not allow the slate to slip as easily as a rope. Two men can elevate the slate with ease with this derrick, which is secured on the roof by means of a platform. This platform may be about 4 feet long by 3 feet wide, supported in front so as to make it level, as shown. The standards A A are toenailed to the platform and the top is fastened as has been described with the rope J. The derrick should lean out over the cornice or eave far enough to avoid striking any projection of the building by the slate in being hoisted.

The man on the ground and the one on the platform can both pull on the rope until the slate is high enough to be pulled in and balanced on the center brace B until the rope or chain is loosened, when the platform man gives the rope a downward throw and while he carries the slate to the roof scaffold the man below loads up again.

A projecting beam derrick can be made as illustrated in Fig. 188 and operated as above described, or a horse may be used on the ground instead of man power by

passing the rope over a snatch block, held firmly to the ground by a stake. The platform may be as already described, the exception being in regard to standards and beam. The latter are made of 2 × 4 oak timber from 10 to 12 feet long, projecting over the eave as at A and passing back of and nailed to a rafter of the roof at D at an elevation giving the desired pitch. It is braced at the platform with two side braces B, which are spread at the bottom, as shown in Fig. 187, and are toenailed and secured to the beam by a bolt at C.

In relaying slate in part, upon a roof undergoing repairs, the row or last course to be laid must be secured by driving the nails between the slate of the row above and covering the nail heads by slipping a strip of galvanized iron over the heads and under the slate.

Or, better still, the last course can be secured in place by nailing strips of sheet metal ½ inch wide, and long enough to extend about 1 inch below the bottom of the slate; then shove slate under the course above and bending the strip over the bottom of slate suspending it in its proper position.

The double Maltese cross design, Fig. 181, is one of the most pleasing designs that can be laid with green and purple slate, having a red relief, as shown by the slate of lighter shade, and withal an easy one to develop. The length of rafters and width of the roof are reduced to inches and the amount divided by the exposed length and width of the slate, giving the number of slate to a course and the number of courses required. When this has been ascertained a rough draft may be made by the workman, similar to Fig. 181, and taken upon the roof, which will show at a glance where each slate on the roof should be located.

In driving nails care should be taken not to draw the slate tight, otherwise freezing weather, followed by a thaw, will crack them, or burst the nail head through, allowing the slate to slip down the roof.

A roof paint bucket made to conform to the pitch of the roof and used in slate roofing for valleys, flashing, etc., is shown in Fig. 189, and may be made in size to conform to the fancy of the workman. For tin or metal roofing, the steel spring band A riveted on each side is intended to engage the standing seam to help prevent the bucket from slipping, and a No. 6 wire across the top, as shown at B, may be used to wipe the brush of excess of paint.

For contract roofing it does not pay to use seconds or No. 2, or do indifferent work, as one poor roof will ruin the reputation of a score of good ones. If a price cannot be gotten that will justify good slate and careful workmanship, it is far better to turn the job down. Your reputation for quality and skill will soon make

itself manifest and you can get fair prices. It has long been said that the foundation of a house and the roof were the important items to consider, and no one able to build at all will object to a fair price if satisfaction is assured.

In making an estimate see that there is a complete and full understanding as to the terms of pay and guarantee of work. If the roof is in the country, never fail to mention hauling the slate to the work and returning that not used; also terms for board, free or otherwise, for your man and horse or team; also specify the price per square for all tin or galvanized iron work, and also that there be a foot of width added as extra for the length of each hip and valley on the roof. If copper nails are to be used, add 25 cents per square extra, otherwise use common galvanized slater's nails. Ridge roll, Fig. 182, should be used on all hips and over the comb and price per foot specified. As it is almost an impossibility to remember all the items to be considered when taking a contract, each roofer should have some simple printed contract form that he may draw up at his leisure to meet his own views, embracing all items that could probably come under dispute, thereby saving himself possible untold annoyance and oftentimes cash.

A SLATER'S ADJUSTABLE SCAFFOLD BRACKET

These are instructions for making a scaffold bracket which can be adjusted to suit various pitches of roofs, and which has its suspending strip of iron so constructed that it can be slipped from under the slates so as to change it to another place on the roof.

It may be said that roofers care very little for the various patented scaffolds and the many schemes of adjustable brackets. They prefer the well-tried method of making brackets out of scrap pieces of wood to be found around buildings, and hanging them from strips of sheet metal. When the scaffolding is being removed these strips are broken off and the part under the slates is left there.

This method of scaffolding is rapid and safe, while with the strip made so as to allow for withdrawing it from under slates there is the positive danger of inadvertently pushing the brackets up, thereby dislodging the strip from its hold on the nails.

A bracket of this type can be easily constructed as follows: Cut two pieces of 1-inch board 6 inches wide, one 30 inches and the other 25½ inches long, and connect them with strong hinges as shown at D in the diagram. The standard C is a piece of 1-inch board, 6 inches wide and 16 inches long. To keep this

standard in place 1 × 1-inch cleats are nailed to the base of the bracket, as shown at E, and the standard is fastened to these cleats by bolts through G, which is made of heavy sheet iron and nailed or screwed to the cleats.

The adjustment to two other roof pitches by one standard is shown by the dotted lines. By using different lengths of standards, adjustment to a greater range of pitch is obtained. Plenty of play should be allowed when spacing these cleats, for it is desirable to keep the standards plumb. It has been found that when using different sized standards it may be necessary to put a standard in, say, the first space of the roof piece H and the second space of the platform or plank rest, piece J.

The strip K is made by a tool maker of tempered steel and the notches cut for as many nails as are deemed necessary to support the load. In this case there are

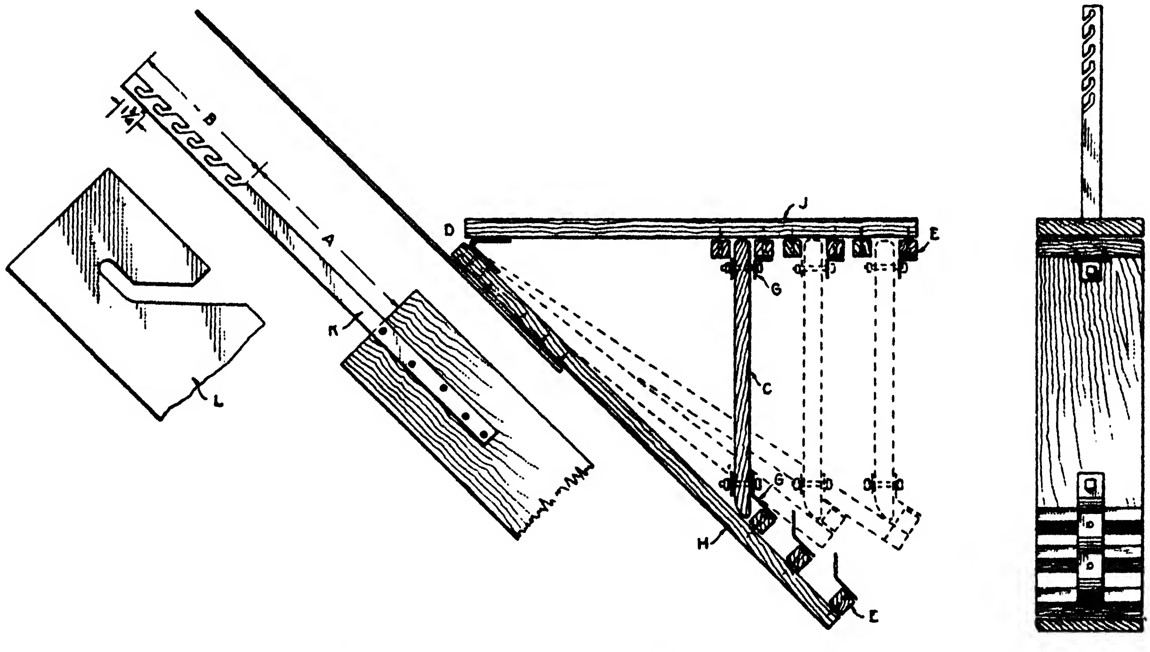


Fig. 190.—Details of a Slater's Adjustable Scaffold Bracket

six. The notch is better shown by L. They are spaced about $1\frac{3}{4}$ inches. The strip is 2 inches wide and 1-16 inch thick. The length A is such that when bracket is placed on the slates the first notch is above the last course of the slates laid and allows the top of the bracket to be down far enough not to interfere with the top of the next course, and just so low that when the bracket is being released from the nails it can be pushed up just the distance required to be slipped from the nails without the bracket hitting the slates.

It is suggested that for a very steep roof like a mansard, a scaffold built up from the eaves and tops of the dormer windows be used in preference to these suspended brackets.

A FALSE-BOTTOM GUTTER

When it is desirable to have a small molded gutter show up level and still have the requisite pitch to the leader, and owing to the gutter being small it would not pay to have a wood lined or box gutter, as described in another part of this book; then the accompanying illustration, Fig. 191, should answer.

This gutter is only a molding on the outside, and can be formed up to suit the job, and is nailed to the fascia board at B. This molding is riveted and soldered at the seams, care being taken, when doing this, not to press on the molding, as it is very easy to push the molding at the seam, thereby having it out of line, and of course crooked.

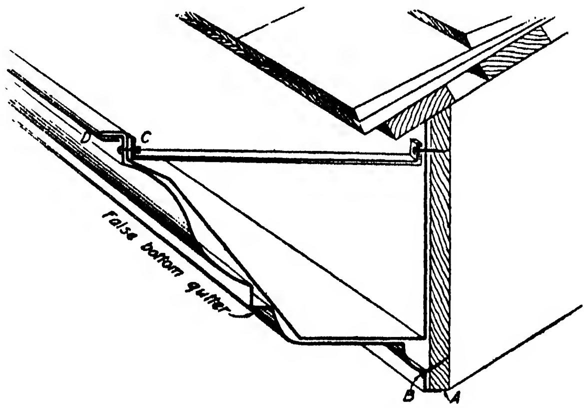


Fig. 191.—View of False Bottom Gutter in Place

After erecting the molding by nailing at B, and holding up the front temporarily, the lining or inside gutter, which has the proper pitch to the leader, is put in, 24 ft. at a stretch, fastening it at D to the molding as shown, and nailing to the fascia in the back. Those seams at the ends of the 24 ft. lengths cannot be readily riveted, therefore, previous to laying in, place these seams together on the ground, looked along the two lengths, and straighten (or use a chalk line). Punch holes as if for rivets, but instead insert 3-16 in. stove bolts, with the nuts on the sides of the gutter, which will be inaccessible when in place; tighten up bolts and solder the nuts, seeing to it that bolts are not soldered; remove the bolts, take the two lengths apart and then they can be set in place in the molding and bolts re-inserted in their places, same as if in a tapped hole, and seams heavily soldered.

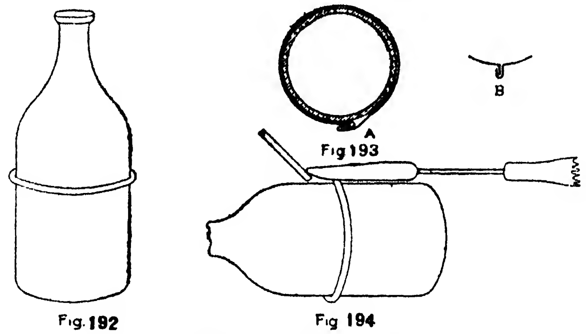
This method of making a false bottom has the additional advantages of allowing for a pitch from the very top of molding to bottom, and should the bottom leak it will be manifest by dripping from the molding at A, which should be suffi-

cient warning to renew bottom before molding becomes rotted also. The braces are made from 1-8 × 1 in. tinned band iron and formed as shown, bolted at C to the gutter and nailed to board at the back. If desired, the bottom could be flanged back on the roof and under shingles or slate, and likewise the brace could be nailed to roof.

MAKING AN ACID CUP FROM A BOTTLE

Some shops furnish the men with a suitable receptacle for the acid in sheet metal soldering. It being a fact, though, that oftentimes, especially on outside work, the men must find something to hold the acid and to allow of dipping in a brush, the following is presented.

Take any clean bottle, such as a beer or soda water bottle, and bind around it a narrow strip of sheet metal as Fig. 192. This strip should be about $\frac{1}{8}$ in. wide and bound as tightly as possible with a lock joint by turning with the pliers small edges as B, Fig. 193 and then dressing them down as A, Fig. 193.



Method of Making Cup.

After this swab some acid on the strip, and with a hot soldering copper, solder around the strip, using some solder of course, and before the bottle and strip have a chance to cool, put acid on the strip, with the brush following the soldering iron as indicated in Fig. 194. This will cause the glass to split on the line of the strip and a light blow will break the lower half of the bottle from the neck. Sometimes the glass is rather tough and the heating and cooling must be repeated two or three times. This is the conventional manner of making these cups and it takes very little time and is certainly worth knowing.

SECTION VI

(Pages 653-784)

SHEET METAL ROOFING PATTERNS

Practical Sheet Metal Work and Demonstrated Patterns

MEASURING ROOFS

This article will give the rules for obtaining the true amount of material required when covering flat or hipped roofs and square, octagonal and conical towers; also the methods of obtaining the true lengths of the hips and valleys on pitched roofs. The diagrams shown herewith are not drawn to a scale as architects' drawings will be, but the measurements on the diagrams are assumed, which will clearly show the principles which must be applied when figuring from scale drawings or from sketches made when measuring the roof itself.

Assuming that the plans from which we are figuring are drawn to a ¼-inch scale, when measurements are taken every ¼ inch represents 1 foot, ⅛ inch equals 6 inches, and so on. If the drawings were drawn to a ½-inch scale, then ½ inch would equal 12 inches, ¼ inch equal 6 inches, ⅛ inch equal 3 inches, 1-16 inch equal 1½ inches, etc. When going estimating a small scale rule 6 inches in length is usually carried in one's pocket with pencil and note book and some loose pads. The title of the items which we propose to take off the plans is usually written as follows:

(Mention name) (What kind)
Estimate to.. for..
(Number, street and city)
roofing for building number...
(Name) (Name) (Name)
Mr...owner; ....and ....
(Number, street and city)
architects; number..

We now read the specifications carefully and note what material is to be used for the roof covering. If tin, note what brand is required and its thickness, IC or IX; if it is to be laid on paper or painted underneath before laying and how many coats will be applied to the top; what size sheets and how many pounds of solder will be used to the square (a square in this connection means a surface space of 10 × 10 feet); and will the tin be laid flat or standing seam. After observing these points the quantities are taken off the plans. If the roof is to be covered with slate, note what size and how thick the slates used are to be; if they are to be nailed on sheathing or porous fire proof blocks, and with galvanized or brass nails; if the slates are to be laid on paper, and if the flashing and valleys are to be of tin, galvanized iron or copper.

Knowing all this we can make our estimate accordingly. Next ascertain if the specifications call for a tile roof and whether shingle tile, Spanish or other form of tile; if they are to be laid, as mentioned, in connection with slate roofing or are to be fastened to the purlin with copper or galvanized wire. All these are important considerations in arriving at a close estimate. If a felt roof is required and the tinner is to attend to the flashing, note how many layers of felt are necessary, also if each layer of felt is to be thoroughly saturated with hot asphalt cement or just coal tar, and if gravel or slag is to be placed over the top layers. If the roof is to be covered with shingles, and assuming that the tin roofer looks after the flashing, note what kind and size of shingles are to be used, how much they will be laid to the weather and what kind of nails are to be employed, etc. We must become familiar with these points in order to figure accurately.

The following are methods of arriving at the amount of roofing required for flat roofs; so to figure the amount of material required on a flat roof, shown in Fig. 1 by A B C D, and which measures 20×20 feet. Multiply 20×20 feet giving 400 square feet. The chimney measures 1×2 feet and equals 2 square feet; deduct this from 400 square feet. Then 398 square feet will be the true amount of surface to be covered on the roof shown in Fig. 1. Allowance should be made for the flashings turning up against and into the wall at the sides. Fig. 2 is a little more difficult, and shows a plan having air shafts at the sides. A B C D represents the general plan view of the roof, which measures 22×84 feet, as shown. In a roof of this kind we will figure as if there were no air shafts at all, and then deduct the shafts and chimneys later. Thus 84×22 feet equals 1848 square feet. The shafts at each side are cut at an angle of 45 degrees, and measure from the outer corners *a* to *b* 20 feet, and from the inner corners *c* to *d* 10 feet. Now, as the angles are 45 degrees, we must average the distance between 10 and 20 feet, which will measure 15 feet, as shown from *e* to *f*. As the distance from *i* to *j* on a horizontal line is 5 feet, multiply 5×15 feet, giving 75 square feet; double this for the two shafts, making 150 square feet.

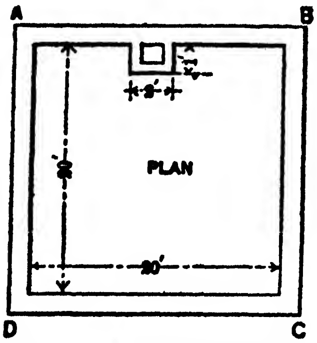


Fig. 1. Plan of Square Roof

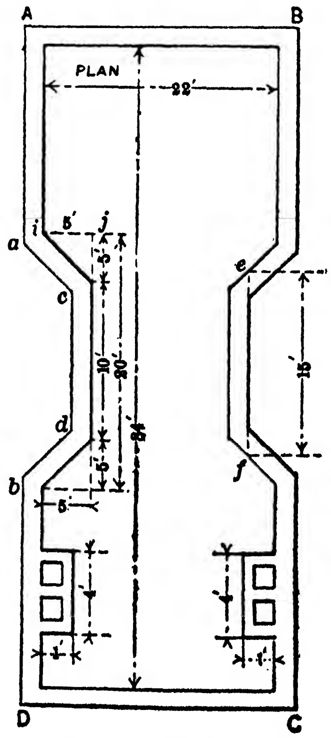


Fig. 2
Roof of Building with Air Shafts at the Sides

Two chimneys are shown, each 1×4 feet, equals 4×2 feet equals 8, plus 150 feet equals 158 square feet. Now deduct 158 square feet from 1848 square feet, leaving 1690 square feet of roof surface in a roof of the dimensions of Fig. 2, minus the flashings.

Another case of flat roof that may arise is shown by A B C D in Fig. 3. In this case the same rule is employed as that given in connection with Fig. 2.

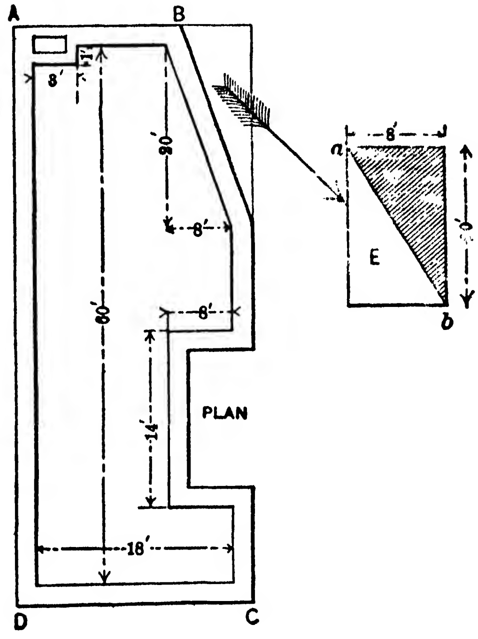


Fig. 3. Another Shape of Flat Roof

Multiply the width by the length in Fig. 3, thus: 18×60 feet equals 1080 square feet if the roof has no breaks. Now deduct the chimney of 1×3 feet, which equals 3 square feet; deduct the shaft of 8×14 feet, which equals 112 square feet. The angle at the rear of the building measures 8×20 feet, which equals 160 square feet; from this deduct one-half, which leaves 80 square feet. Now then we have 3 + 112 + 80 feet equals 195 square feet to be deducted from 1080 square feet, which leaves 885 square feet of material required to cover a surface of the size given. In diagram E is shown the principle which is applied when figuring the deduction of angles. The size of the square is 8×20 feet and equals 160 square feet, as mentioned. Now by drawing the diagonal *a b* we cut this amount in half, as shown by the shaded lines, and will make it 80 square feet, as noted.

We now have pitched roofs, as shown in Fig. 4, in which A B C shows the front view of the building and D E F G the side. The length of the rafter measures 12 feet, as shown from A to B in front view, and the length from G to F on the side view measures 66 feet. Now 12×66 feet equals 792 square feet for one side. Double this and we have 1584 square feet. Now deduct the chimney, which is 6 feet wide by 2 feet, shown on the rake; 2×6 feet equals 12 square feet, which deduct from 1584 square feet, and leaves 1572 square feet for a plain pitched roof.

In Fig. 5 A B C shows the elevation of a pitched roof having four hips, and D E F G the plan of the hipped roof. The diagonal lines shown from D to F and E to G show the hip lines in plan. While it may appear difficult to some to figure the quantities in a hipped roof, it is very simple, if the rule is understood. The length of the rafter shown from A to C in elevation is 10 feet and the width

of the building at the eaves of the roof is 16 feet on each side, as shown in plan. As the hipped roof runs to an apex in the center, then the distance between the eave line D E and apex *a* in plan will measure one-half of 16 feet, or 8 feet, as

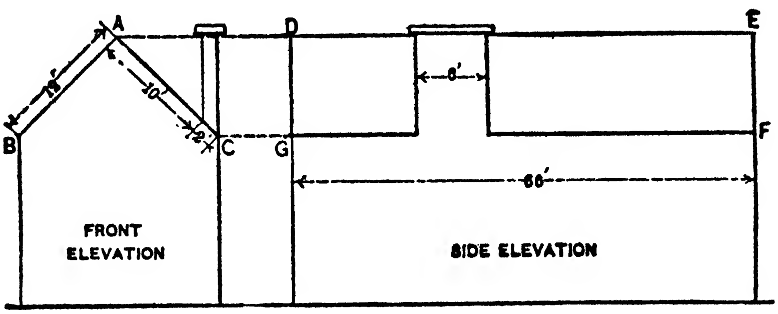


Fig. 4. Simple Form of Pitched Roof

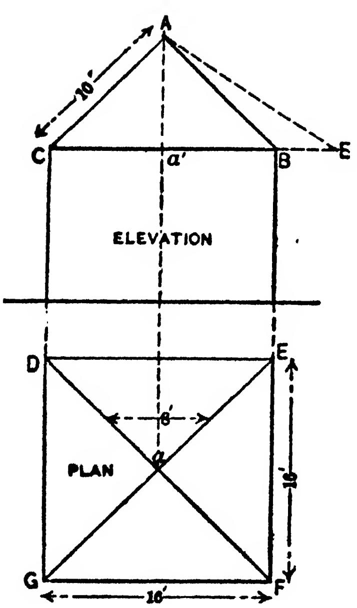


Fig. 5. Pitched Roof with Four Hips

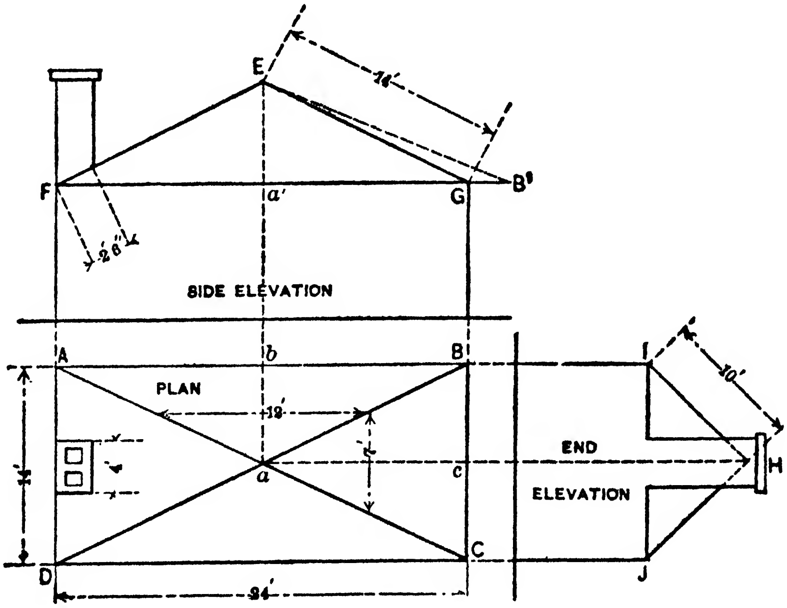


Fig. 6. Diagram Showing Method of Estimating Hip Roofs of Unequal Pitch

shown. Now multiply 8×10 feet equals 80 feet by 4 sides equals 320 square feet of roofing required on a building of the dimensions given. As the hips must be covered with a metal capping to avoid leakage on roofs, it becomes necessary to learn how to obtain the true length of the hip. This is accomplished by dropping

a line from the apex A in elevation, cutting the line C B at a'. Now extend the line C B as C E^1. Now take the distance of the diagonal a E in plan, and place it as shown from a' to E^1 in elevation, and draw a line from E^1 to A, which will represent the true length of the hip. Multiplying this amount by 4 will give the amount of capping or ridge roll required on a hipped roof of the size given.

The method of estimating hipped roofs when the sides are of unequal pitch is explained in connection with Fig. 6. A B C D shows the plan of the roof, the ends measuring 14 feet and the sides 24 feet. The side view is indicated by E F G, showing the rafters of 14 feet length, and the end view by H I J, with rafters of 10 feet length. As the length of D C in plan is 24 feet, then will the averaged distance between a and b be 12 feet, while using the same rule the averaged distance between a and c is 7 feet. Now multiply the length of the rafter I H in end view, which is 10 × 12 feet in plan, which equals 120 feet; twice this is 240 feet. In similar manner multiply the length of the rafter E G in side view, which is 14 × 7 feet in plan, which equals 98 feet; twice this equals 196 feet, plus 240 feet equals 436 square feet. Deduct the chimney, which measures 2 feet 6 inches in side elevation by 4 feet in plan and equals 10 feet; deduct this from 436 square feet, which leaves 426 square feet of covering required for an unequal pitched roof, as shown in Fig. 6. For the length of the hip take the distance from A to B in plan and place it on the line F G extended in side view from a' to B^1. Then draw a line from B^1 to E, which is the true length of the hip for one corner.

A more difficult problem in roof measurements is illustrated by Fig. 7, in which a deck and mansard roof is shown, with intersecting dormers. A B C D shows the side view and A^1 B^1 C^1 D^1 the end view. The plan of the mansard and deck roof is shown by E F G H and I J K L, the dormers being indicated in the views, as shown. It is desired to see how much roofing material will be required to cover the mansard and deck roofs, also the tops and the cheeks of the dormers; also how much hip ridge for the roofs and valleys for the dormers will be needed.

The roof measures at the eaves 18×32 feet, and at the deck 6×20 feet. Now multiply 6 × 20 feet equals 120 square feet; the chimney is 3 feet by 1 foot 6 inches, and equals 4 feet 6 inches. Deducting this will leave 115½ square feet of surface on the deck roof. Now average the distances between the eave lines E F and E H and deck lines L I and I J, as follows: 32—20 feet equals 12 feet, divided by 2 equals 6 feet. Now either add 6 feet to 20 feet or deduct 6 feet from 32 feet, which will leave 26 feet, as shown. In similar manner average the end, obtaining the amount of 12 feet, as shown. As the length of the rafters in both

end and side views measures 14 feet, then multiply 14×26 feet giving 364 feet, multiplied by 2 sides giving 728 square feet. Then again 14×12 feet equals 168× 2 ends equals 336 square feet, making a total of 1064 square feet. We now deduct the dormers. The length of the dormer cutting into the main roof from *h* to *j* in side view is 8 feet 6 inches; the length of the cheek from *h* to *i* is 6 feet; the width of the dormer in plan is 4 feet. Now multiply 4 × 6 feet equals 24 feet by 4 dormers equals 96 square feet. The width of the pitched roof of the dormer cutting onto the mansard roof on the rake is 2 feet 6 inches, as shown in side view,

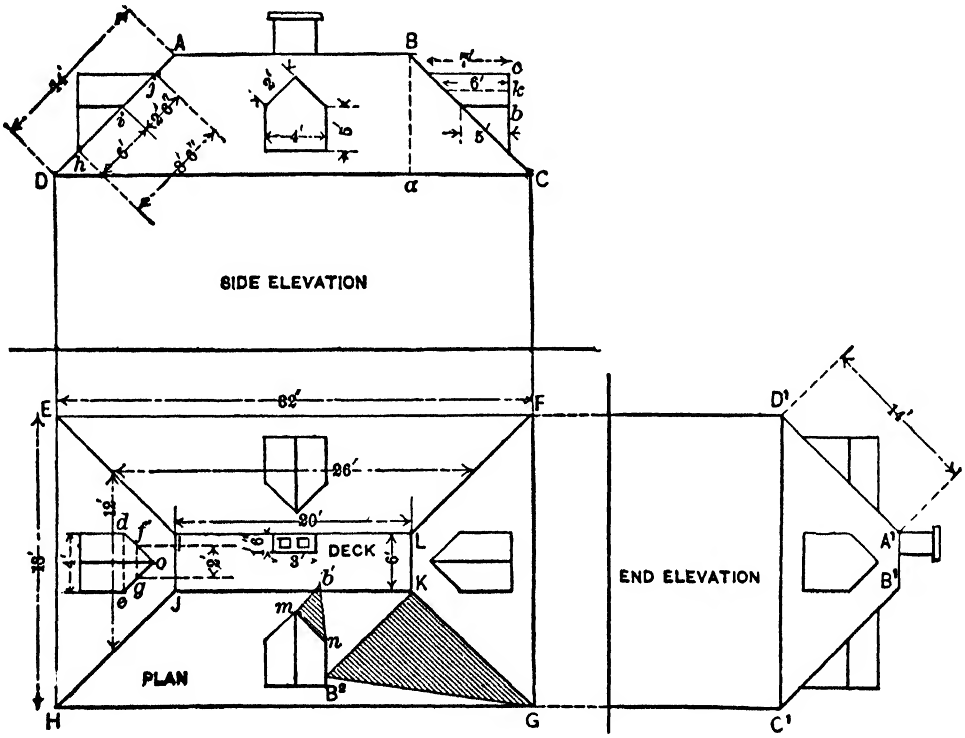


Fig. 7. Plan and Elevation of Mansard Roof with Deck and Dormers

while the averaged distance in the plan view of the dormer, between the line *d e* and the apex *o*, as shown from *f* to *g*, is 2 feet. Then 2×2 feet 6 inches equals 5 feet, multiplied by 4 dormers equals 20 feet. Now add 96 feet and 20 feet equals 116 square feet to be deducted from 1064 feet and leaves 948 square feet in the mansard roof minus the dormers. The covering for the cheeks and dormers is as follows: The hight of the cheek is 5 feet and the width of the cheek is 5 feet; 5×5 feet equals 25 feet, multiplied by 4 dormers equals 100 square feet. The pitch on the roof of the dormer equals 2 feet, as shown, while the averaged distance

between the eave line b of the dormer and the ridge line c is shown by k, which is 6 feet. Then 6×2 feet equals 12 feet, multiplied by 8 roofs of dormers equals 96 square feet. We then have:

115½	square feet in deck roof,
948	square feet in mansard roof,
100	square feet in cheeks of dormers,
96	square feet in roofs of dormers, making a total of

1259½ square feet of material required for the mansard and deck shown. In previous problems the length of the hip was obtained from the elevation; in this one we will show how it is obtained from the plan, either method being desirable. From the point B in side view drop the vertical line B a, intersecting the line D C, as shown. Now take the distance a B and place it at right angles to K G in plan, as shown by K B^2. Draw a line from B^2 to G, which will be the true length of the hipped ridge or rafter. In similar manner the length of the valley behind the dormer is obtained. Take the hight of the roof of the dormer $b\ c$ in side view and place it at right angles to the valley line of the dormer $m\ n$ in plan, as shown by $m\ b'$. Draw a line from b' to n, which is the true length of the valley. Eight times this amount will be required, whether made of tin, zinc, galvanized iron or copper.

Fig. 8 shows a hipped roof with wing attached. Only special attention will be given to those parts which have not been explained previously. Assuming that the main building were minus the wing, it would be figured in similar manner as explained in connection with Fig. 6. We would, however, in this case have to deduct the space taken up on the roof for the chimney in Fig. 8, and deduct the space where the wing intersects the main roof. The chimney is 8×8 feet in size, as shown in plan, and intersects the pitch of the roof at a distance of 6 feet, as shown in front elevation. Now average the distance in plan between the apex a and the side of the chimney $b\ c$, as shown from f to h, which is 4 feet; then 4×6 feet equals 24 square feet. Now in the side elevation the chimney cuts into the pitch roof also at a distance of 6 feet, as shown.

The line of the chimney in plan $c\ i$ equals 8 feet, and the ridge line, as far as chimney intersects it, from a to j, measures 4 feet. Then average the distance between $a\ j$ and $c\ i$, which is 6 feet and is shown by $h\ k$. Then 6×6 equals 36 feet, multiplied by 2 sides equals 72 feet, plus 24 feet for the front equals 96 square feet, which would be deducted from the main roof covering. The space which will be deducted from the side of the main roof to admit the intersection of the wing is obtained as follows: The width of the wing in plan is 30 feet. Now average the

distance between the points *m n* and the apex *o*, which will measure 15 feet, as shown from *r* to *t*. Now multiply 15 feet by the length of the rafter *y z* in side elevation, or 20 feet, which equals 300 square feet, also to be deducted from the main roof. For the amount of roof surface in the wing only proceed as follows: The length of the ridge from *o* to *v′* is 35 feet and the length of the eave from *n* to

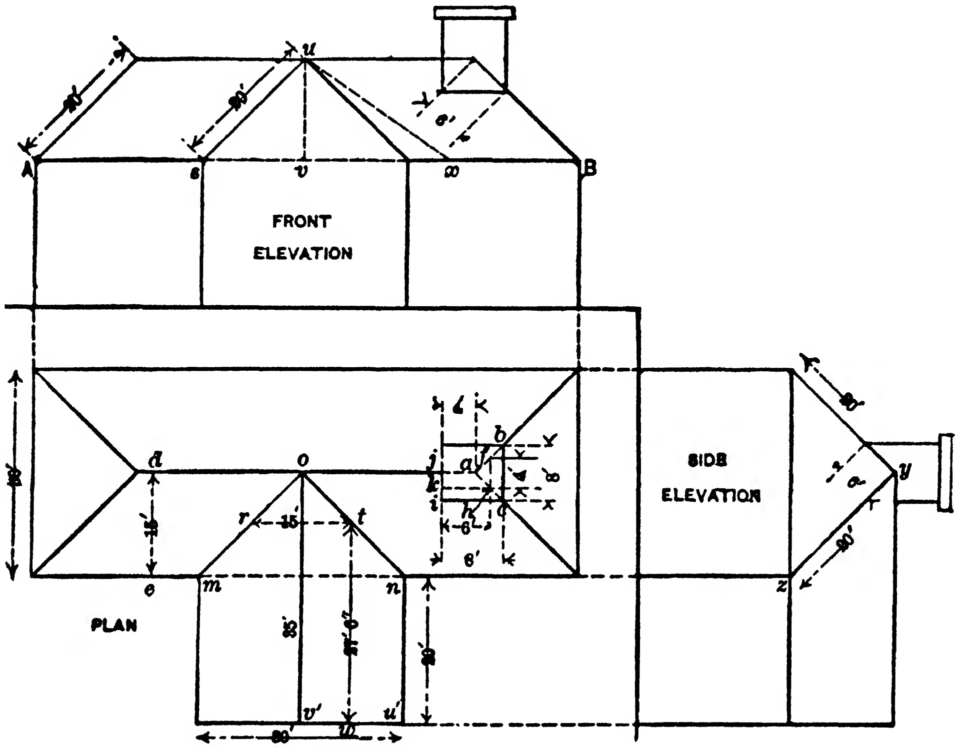


Fig. 8. Plan and Elevations of Hip Roof with Wing Attached

u′ is 20 feet. Now average the distance between the eave and the ridge, which will be 27 feet 6 inches, as shown from *t* to *w*. Now multiply this by the length of the rafter *u s* in front elevation, which is 20 feet; thus 27 feet 6 inches multiplied by 20 feet equals 550 square feet, multiplied by 2 sides equals 1100 square feet of surface on the roof of wing. To obtain the length of the valley, *o n* in plan, drop a line from the apex *u* in front elevation until it intersects the line A B at *v*; now take the distance *o n* in plan and place in front elevation from *v* to *x* and draw a line from *x* to *u*, which will be the true length of the valley and at the same time the true length of the hip, because the end of the wing and the ends of the main building each measure 30 feet.

In Fig. 9 only that portion will be shown which has not been explained in previous figures, and that is, how much will be deducted from the side of the main

roof to admit the intersection of the wing. Referring to the elevation, the wing intersects the main roof at a distance of 7 feet, as shown, and the width of the wing in plan is 10 feet. Now average the distance between the apex *b* and points of intersection *d* and *a* in plan, which will be 5 feet, as shown from *f* to *h*. Then multiply 5×7 feet equals 35 square feet to be deducted from the side of the main roof. The length of the valley is obtained by taking the distance *a b* in plan and placing

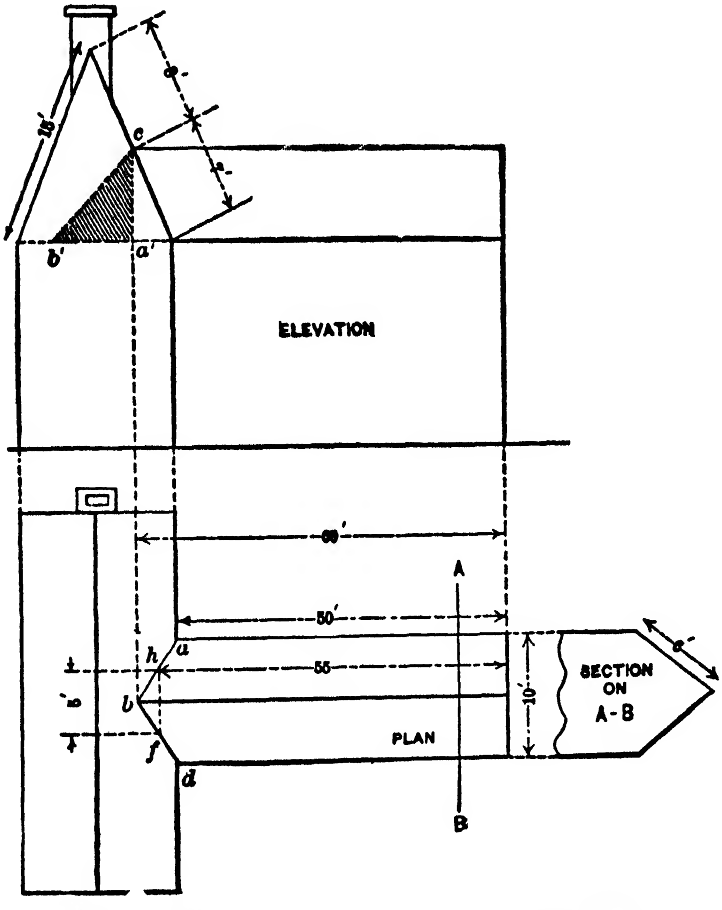


Fig. 9. Diagrams Showing Amount to be Deducted from Side Main Roof to Allow for Wing

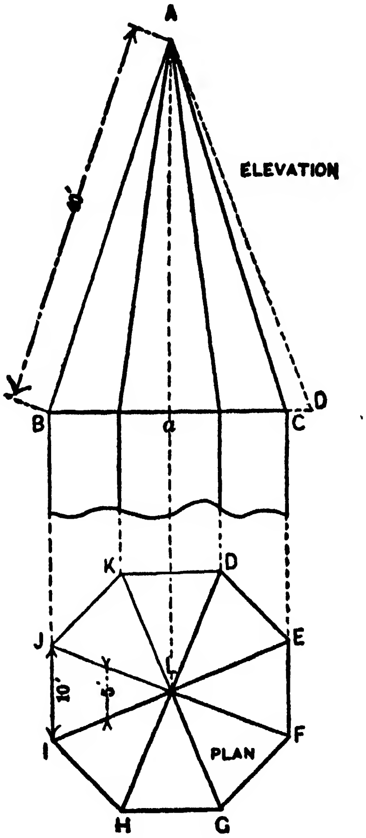


Fig. 10. Finding Quantities in a Tower of Any Shaped Base

it as shown from *a′* to *b′* and drawing the line *b′ c*, which will be the true length of the valley.

In Fig. 10 is indicated the method of finding the quantities in a turret or tower whose base is either square, hexagon, octagon or any other shaped figure. Let A B C represent the elevation of the tower, whose plan on B C is shown by D E F G H I J K. Lines drawn to the center L in plan, as shown, represent the hip lines. Now, assuming that one side of the tower, J I in plan, measures 10 feet,

then average the distance between J I and the apex L, which will be 5 feet, as shown. The length of the rafter shown from A to B in elevation being 40 feet, then 40 × 5 feet equals 200 feet, multiplied by 8 sides equals 1600 square feet

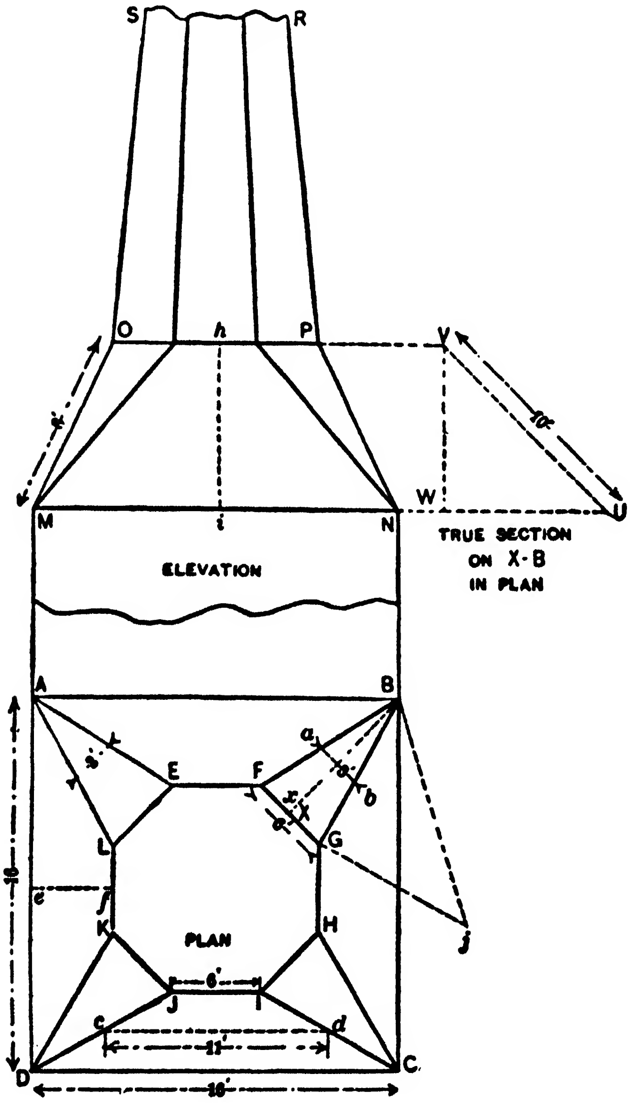


Fig. 11. Octagon Tower with Square Base

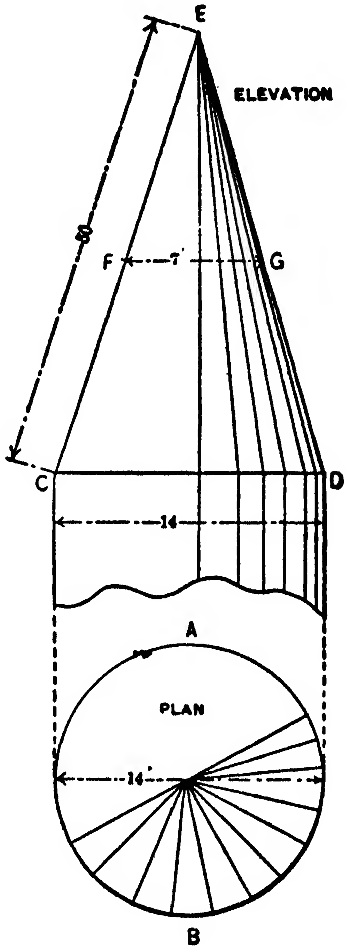


Fig. 12. Plan and Elevation of Conical Spire

surface in the tower of the dimensions given. For the length of the hip draw the center line A L, intersecting the line B C in elevation at *a;* then take the distance of one of the hips in plan, as L D, and place it as shown from *a* to D[1] in elevation. Draw a line from D[1] to A, which is the true amount of the hip, which must be multiplied by 8 for the full amount of the eight hips.

Here is shown a more difficult problem in figuring roof surfaces, as illustrated in Fig. 11. Here A B C D represents the square base of a tower or other object, from which a transition to an octagon takes place, as shown in plan by E F G H I J K L, the elevation of the tower or other subject being shown by M N O P R S. It is this portion, shown by M N P O, which forms our lesson. The length of the rafter from O to M in elevation is 8 feet and is the true section on the line *e f* in plan. As the base line in plan is 16 feet and the top line in octagonal plan is 6 feet, average the distance between the two as follows: 16 feet minus 6 feet equals 10 feet, divided by 2 equals 5 feet, plus 6 feet equals 11 feet, as shown by *c d*. Now multiply 8×11 feet equals 88 feet multiplied by 4 sides equals 352 square feet for the four sides. For the gore piece F G B in plan it will first be necessary to find the true length of the rafter on X B in plan. This is accomplished by taking the distance X B and placing it on the line M N in elevation extended, as shown by W U.

At right angles to W U draw the line W V until it meets the line O P extended, as shown. Draw a line from V to U, which will be the true section on X B in plan. The distance from F to G in plan measures 6 feet. Now average the distance between these points and the corner B, as shown by *a b*, which is 3 feet. Now, assuming that V U in elevation measures 10 feet, multiply this by 3 feet, equals 30 feet, multiplied 4 times equals 120 square feet for the gores. Add 352 square feet for sides, which will make 472 square feet of roof surfaces in the transition piece shown. The length of the hip is obtained by taking the vertical hight in elevation *h i* and placing it in plan at right angles to B G from G to *j*; then draw a line from *j* to B, which will be the true length of the hip, which must be multiplied by 8 for the full amount for the eight hips.

Fig. 12 gives the method employed when estimating on conical spires or towers. Assuming that the base of the spire, C D in elevation, is 14 feet, as shown by A B in plan, then average the distance between the base C D and the apex E in elevation by dividing 14 by 2, which will be 7 feet, as shown by F G. As the circumference of a circle is found by multiplying the diameter by 3.1416, or, as used in practice, 3 1-7, then multiply 7×3 1-7 feet equals 22 square feet. The length of the rafter being 30×22 feet equals 660 square feet of surface in a spire of the dimensions shown in Fig. 12.

THE PITCH OF ROOFS

There seems to be a diversity of opinion in the trade regarding the question of the proper designation of the pitch of a roof.

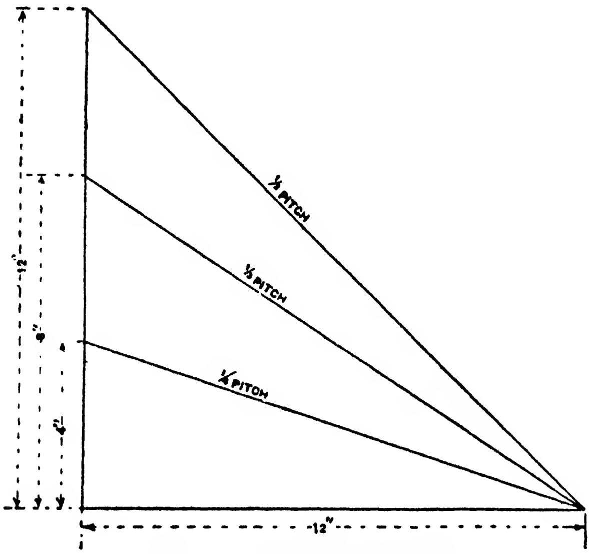


Fig. 13. The Pitch of Roofs

It is generally recognized that the pitch of a roof is measured in parts of the span. For example, if a building is 24 feet wide and the rise of the rafters is 4 feet, the pitch would be one-sixth, Fig. 13. If the rise was 8 feet the pitch would be one-third; if the rise was 12 feet the pitch would be one-half, and if the rise was 16 feet the pitch would be two-thirds. In some sections it is customary to indicate the pitch in degrees of a circle, which is the most comprehensive and should be universally adopted.

MEASURING ROUGH FRAMING FOR SHEET METAL CONSTRUCTION

In the following article will be described how measurements are taken from rough framing at the building, whether the framing is of wood or angle iron, and how the details are laid out in the shop for the sheet metal covering.

For a practical example, there has been selected a belfry, such as was worked out in the shop, showing how to proceed in a job of this kind. It will be assumed that Fig. 14 is the architect's scale drawing of a belfry, square in plan, sitting over the ridge of a main roof. The base is of slate with copper hip ridges and projecting cornice. The roof of the belfry is also copper, in which a scuttle is

provided. The four sides have circular arches with round and square pilasters capped by a projecting cornice, over which the spire is slated, the hips being finished with copper hip tile. Over the apex of the spire a cross not shown is placed.

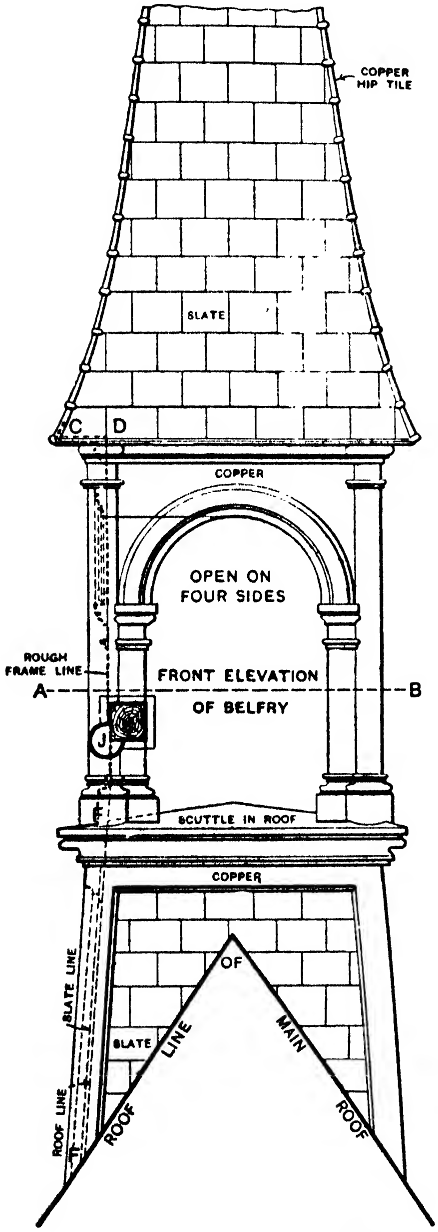


Fig. 14. Front Elevation of Belfry

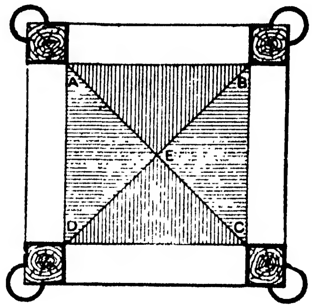


Fig. 15. Section through A B in Fig. 14

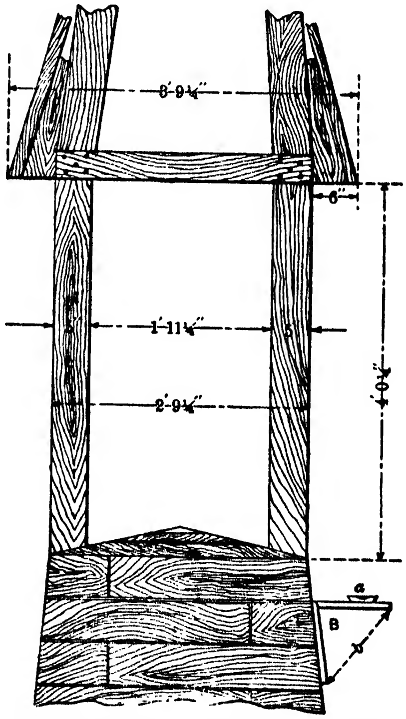


Fig. 16. Taking Measurements from Framing

When receiving a drawing of this kind, we look for a horizontal section through A B, which is shown in Fig. 15, and find that the wooden uprights are incased with metal. This forms the basis for taking measurements at the building.

In work of this kind the framer or carpenter and sheet metal worker work together, so as to avoid any errors. The framing for the belfry looked as shown in Fig. 16. Now all that was necessary to measure was the width of the uprights, which was 5 in., and the distance between the uprights 1 ft. 11¼ in., making the distance from out to out 2 ft. 9¼ in.

The eave of the roof of the spire projects 6 in. on each side, making the total width of the eave 3 ft. 9¼ in. The finial measurement is the hight from eave of spire roof to eave of belfry roof, which is 4 ft. ¼ in. The bevel of the belfry base is now taken by setting the bevel B in the position shown, until the upper arm is in a level position, which is proved by setting on the small spirit level *a*. The distance is now noted between the arms as *b*. The bevel is now closed and can be opened to this distance when making the detail in the shop.

When drawing the detail one-half is all that is required. In Fig. 14 C D E F shows the outline of the frame measurements taken from Fig. 16. Outside of this outline in Fig. 14, the profile of the sheet metal work is drawn as indicated by the dotted lines. A section of a pilaster placed in its proper position is indicated at J. Notice that the curved molding of the arch comes outside of the frame line and that the ceiling of the arch miters as shown in Fig. 15, by A B C D E. Having drawn this one-half face the patterns can then be laid out, finishing two full faces in the shop and joining the other two on the job. When drawing the outline of the metal work around the frame line, play room should be given, so that the metal work will fit easily around the framework, without any cutting of the wood or metal.

TIN ROOFING

The lasting qualities of terne plate, and if it is better made than in the time of our fathers, has been argued pro and con. The question of whether a standing or a flat seam is best; cleats or nails through sheets; provisions for expansion and contraction, specification for good tin roofing; paint; the sheathing; whether to use paper or not under tin. All these and many more have been discussed. The gist of these disquisitions is reprinted in these series.

Sheet metal tiles and shingles, are not considered as they are manufactured articles in a variety of styles and the method of application is as varied and will require more space than is here available.

SPECIFICATIONS FOR A TIN ROOF

The language of most architects' specifications is ambiguous and while competition makes it necessary to deviate considerably from the best methods it is well for those who desire to have the best methods or to safeguard the prestige of tin roofing to have a clear, comprehensive specification. Though some may discredit the use of cleats it cannot be gainsaid that nailing through the sheets leaves a weak point at the nails as shown in Fig. 17, for the nail will be almost to the edge of lock and sometimes exposed, and as nails are usually dirty, often rusted, the solder will not take. And of course there is no provision for expansion and contraction when nails are driven through sheets.

From the many discussions on tin roofing and a number of specifications presented the following has been selected as being representative:

Specifications

A sheathing will be provided of good, well seasoned lumber, narrow widths, free from knot holes and of even thickness. The boards will be laid with tight joints, or shall be tongued and grooved; nail heads well driven in. Sheathing shall be white pine or spruce.

All tin used for roofing all parts of this building shall be X, or Y or Z brand. No substitute for the above grade or brand will be allowed, and the same is to be purchased from the jobber or manufacturer in boxes.

The sheets used for standing seam roofing shall be made up into long lengths in shop. The cross seams shall be locked together and well soaked with solder. One coat of paint shall be applied to the under side before laying.

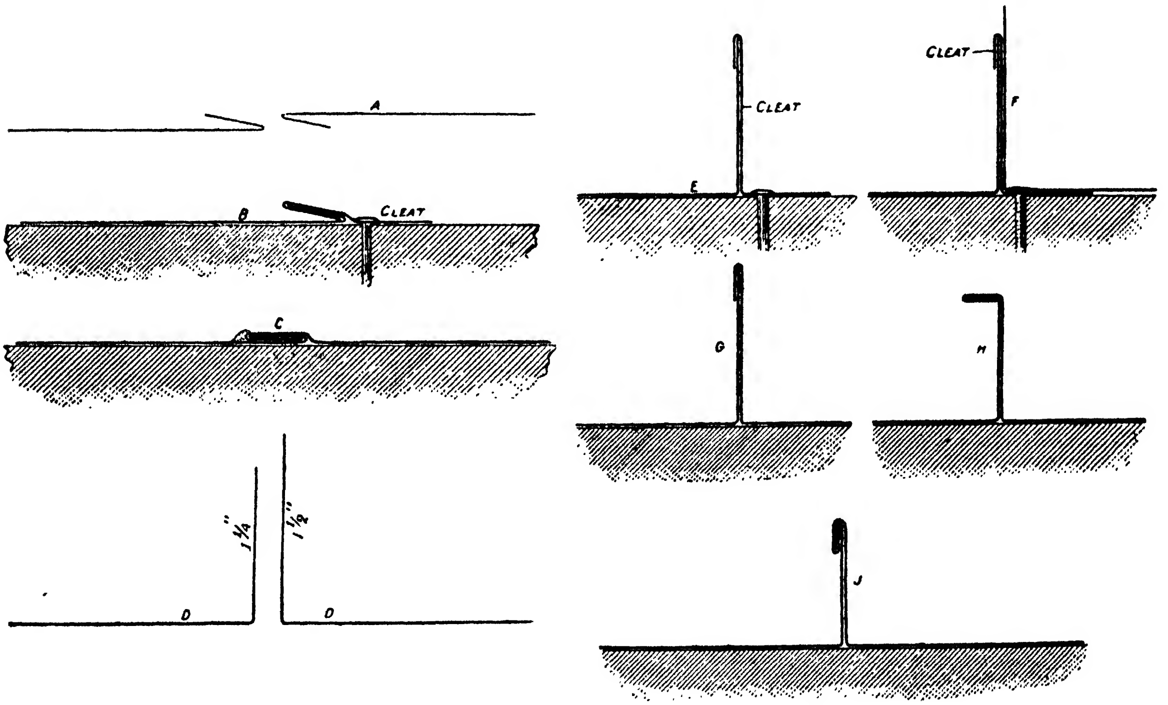
If the sheets are laid singly the size shall be 14×20, painted one coat on under side before laying. The sheets shall be fastened to the sheathing boards by cleats, using three to each sheet, two on the long side, one on the short side. Two 1-in. barbed wire nails to each cleat, no nails to be driven through the sheets.

All seams whether locked or standing shall be made according to the accompanying diagrams. No nails shall be driven through the sheets.

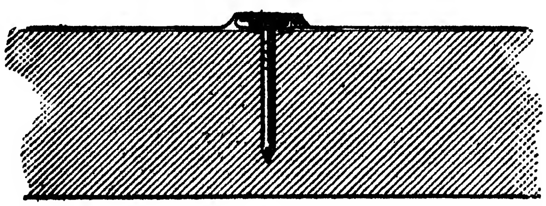
All tin used for standing seam roofing shall be applied the narrow way, fastened to the roof with cleats spaced 8 in. apart. Cleats locked into the seam and fastened with two 1-in. barbed wire nails to each cleat.

All flat seam roofing shall be applied the narrow way, fastened to the roof with cleats spaced 8 in. apart, cleats locked into the seam and fastened to the roof with two 1-in. barbed wire nails to each cleat.

The edges for standing seam roofing shall be turned up not less than 1¼ in. at right angles to the roof when the cleats shall be installed. Then another course



Method of Making Flat and Standing Seams



Weak Points of Seams Nailed Through Sheets
Fig. 17.

with 1½-in. edge turned up. Adjoined edges shall be locked together and the seams so formed shall be flattened to a rounded edge.

The valleys shall be formed with flat seams using sheets the narrow way.

All solder used on this roof shall be of the best grade and guaranteed one-half

and one-half solder (one-half tin and one-half lead), using nothing but rosin as a flux. Solder to be well sweated into all seams and joints.

Surface of tin to be carefully cleaned from all rosin before the paint is applied.

All tin shall be painted one coat on the under side and two coats on all exposed surfaces. The first coat shall be applied to the upper side immediately after laying with a hand brush, well rubbed in. The second coat shall be applied in a similar manner in not less than two weeks after the first coat has been put on. All paint used shall be of the best matallic brown mixed with pure linseed oil, japan only as a dryer. No patent dryer or turpentine shall be used.

No unnecessary walking over the roof or using the same for storage of other material shall be allowed When necessary to walk over the roof, care must be exercised not to break the coating of the tin. Particular care and attention must be given to the laying of the gutters that, when finished, there shall be sufficient pitch to prevent any water standing therein.

No deviation from these specifications shall be made. They must be carried out in every particular. A first-class roof only will be accepted.

When paper is specified the same is to be of the waterproof kind. Paper is not recommended.

Explanation of Diagrams

Flat seam roofing when the sheets are laid in strips or one at a time.

AA shows sheets with edge turned ready for locking.

B sheet or strip laid with cleat locked over turned up edge. The cleat is 1½-in. wide. Two 1-in. barbed wire nails are driven through the cleat into the roof sheathing. These nails must be driven close as possible to the edge of the sheet, otherwise the cleat will have too much play. Cleats must be spaced 8 in. apart.

C, seam or joint completed by locking the two edges A and B together and soldering. The cleat is not shown.

Standing Seam Roofing

DD, edges of sheets or strips turned up at right angles to the roof not less than 1¼ and 1½ in. respectively.

E, sheet or strip laid with cleat locked over upturned edge. Cleats spaced 8 in. apart and fastened with two 1-in. barbed wire nails.

F, opposite sheet or strip laid in place.

G, edges of the two sheets or strips locked together. Cleat not shown.

H, second operation of locking the edges.

J, the standing seam complete.

SOME OBSERVATIONS ON ROOFS

There always has and always will be a large field for roofs made of sheet metal. Copper is the best, when the first cost is not minded, and after years of use is a first-class investment for one who has the money. Terne plates undoubtedly come next, providing they are rightly made and laid. Some makers in this country are making just as good terne plates as were ever made in Wales. The quality of material in the coating mixture, the quality of the oil in the flux, the proper alloying and laying on the base sheet are just as honest now as in any period of previous manufacture. The coating is better applied to the sheet. Every inch of sheet is better covered and protected and worth more than formerly.

If every one who bought terne plate took the trouble to get best plates, with not less than 40 lb. coating per box, there would be less trouble with tin roofs than now, provided the plates were rightly made into a roof on the spot. The best makers will sustain any effort made toward confining consumption of terne plate to the best quality, but when you get it it can be spoiled by the way it is mishandled. It does not purport to be a sheet metal which will withstand nonprotection.

Protection is made by paint. Everybody should know that he should paint a tin roof. Good paint can be had at low prices. Do not make the mistake that the least possible of the cheapest paint is good enough for a tin roof, and do not complain of roof being useless when no paint at all is used. Do not, after laying, leave roof unpainted so long that it gets rusted; some painters claim that paint clings better to a rusty roof, but this is an idea only of theirs—slightly easier and more agreeable to the painter to follow. It is a fact that it is easier if plate is made by palm oil process to wait until by exposure the grease is removed; but such delay cuts short the life of the roof. Put enough paint on both sides, and use it often enough on the upper side, every three years, and use good paint. You will have to do this to counteract disintegration. Give this advice and you will cause those in interest to think well of you and your experience. Saying farther: Do not use acid flux on the seams, but always resin. Solder with an iron hot enough to soak solder well into seams but not so hot as to burn the tin from the plate.

As to fire protection. Metal roofs are the best, returning to tin because it is the cheapest giving same results. You will find parties who are laying roofs with about same material that you take to build your fire. These parties claim and proove to you that their roofs will not burn. Prepared roofs of composition do

burn occasionally, and more furiously than a tin roof, no matter what is said about it. The best prepared composition roofing has been known to burn through in less than 7 min. Tin alone takes more than twice the time; and if you want it to stand still longer in fire first put under the tin when laying the same an impervious felt of 11 lb. to the 100 sq. ft. Back this by an asbestos laying of 16 lb. to 100 sq. ft. and you will further reduce conducting of heat by a full half, bearing in mind that such a roof as last named is of great importance in retarding progress of conflagration.

Other advantages. A roof of good tin is extremely durable, weather proof, fireproof, lightning proof It has a particularly neat, attractive appearance, especially where laid with standing seams. It is clean and sanitary, and therefore especially recommended for use where rain water is collected in cisterns. It is not affected by heat or cold. The slight expansion and contraction of the metal are taken care of by the cleats used to fasten the tin to the roof, which allow a sufficient play. With all these advantages, good tin is extremely light in weight, an important point often overlooked. It is not easily damaged by being walked on.

Finally, a good tin roof is easily repaired in case of accidental damage. These repairs can be made quickly and cheaply without allowing serious damage to the building, no matter what the weather conditions may be.

The foregoing outlines are points that relate to the making of a good tin roof, and if you will frankly tell your customers the facts and show them that final economy is not to be had by cheapest materials or methods it need not surprise you to find that those who are paying the bills want something that will last.

A PRACTICAL TALK ON TIN ROOFING—I

In discussing the subject of tin roofing nearly all members of the trade agree that flat seam roofs put on at the present time do not as a rule give as good satisfaction as those of 50 years ago. While opinions differ as to why this is so, probably a large majority hold to the belief that it is due solely to the difference in the quality of the tin used then and that put on the market now. But any one engaged in this line of work will do well to bear in mind the sentiment of the saying that "a chain is no stronger than its weakest link," for no matter how good the tin used, if the sheathing boards are unsuitable for the purpose or the workmanship poor in any particular, the extra quality of the tin counts for very little.

That there are large quantities of poor tin on the market every one must admit, but it is equally true that well coated sheets are to be had if one will pay the price, and if these are used and the necessary care and judgment exercised in doing the work, tin roofs can be put on to-day that will prove as durable as any in former years. In any discussion as to how to put on good tin roofs or how to avoid poor ones, there is one fact that must not be overlooked and will not be by the most ex-

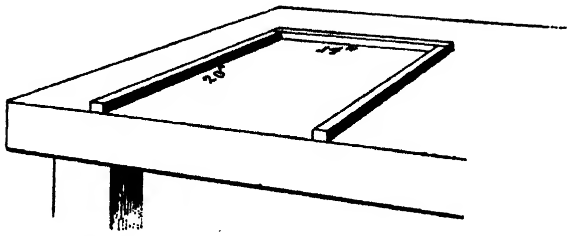


Fig. 18. Frame for Painting Sheets

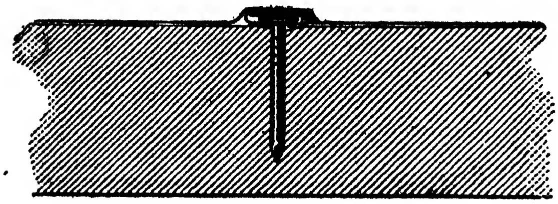


Fig. 24. Weak Point when Nailed Through Seam

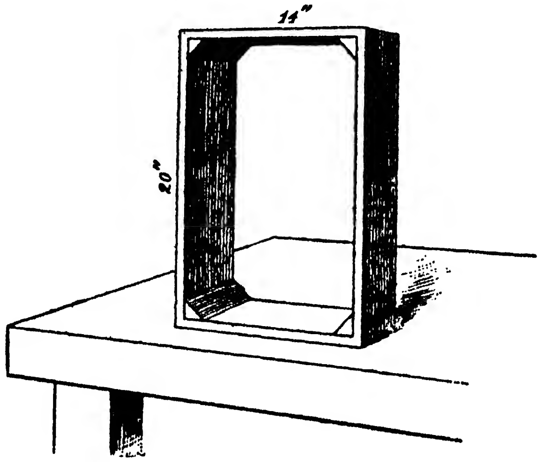


Fig. 19. Guide for Protecting Edges

Fig. 20.
The Painted Sheet

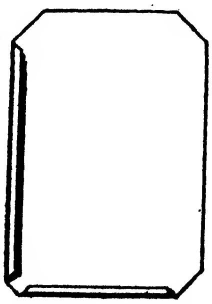


Fig. 21.
Improperly Notched Sheet

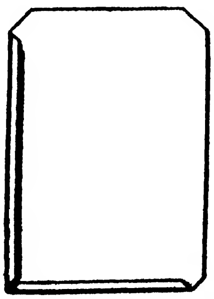


Fig. 22.
Properly Notched Sheet

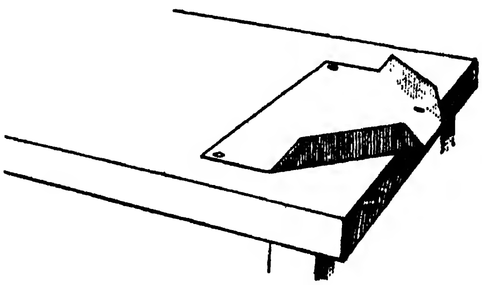


Fig. 23.
Guide for Notching Sheets

perienced and observing among the trade, and that is that tin plate as a roof covering is not a success unless conditions under the roof are favorable. If put on a building in which there is steam or gases that are injurious to metals, no tin will last, no matter how good the quality. Again, if put on a kitchen that is not plastered overhead but just ceiled, the steam from the cooking, combined with the condensation, will put out of business the best tin plate ever made, and it will not take very long to do it either.

A campaign for better roofing is a much needed one, but it must be a campaign of education or it will avail but little. Nearly every one engaged in this line of work is possessed of the necessary mechanical skill to do good work, but what they lack, or many of them at least, is a knowledge of the theory of it. Just as long as tin is used where the temperature underneath is at times from 60 to 90 degrees warmer than on the outer surface, just so long will complaints be heard about the poor quality of tin. No one need get the idea that the tin made 40 or 50 years ago would stand such conditions, for it never was nor never could be made to stand it.

That there is room for improvement in the quality of roofing tin is manifest to every one in the business of laying roofs, but there is just as much need for a better understanding of the conditions under which tin can be used with success and where it can't. Good sheathing boards, good tin and good workmanship are all necessary, but with all these a short lived roof will be the result unless the under side of the roof is ventilated in every instance where ventilation is necessary to prevent condensation. The average architect thinks his duty done when he has specified a certain brand of tin to be used and then holds the roofer responsible for its lasting qualities, regardless of whether conditions under the roof are favorable or not. It is for this reason, if for no other, that the roofer should look more into the matter of what conditions are favorable to tin plate, and then he is in a position to warn architects, builders and owners of what to expect if they insist upon having tin laid where it is impossible for it to last. It is far easier to fix the responsibility where it belongs before the work is done, and, besides, neither architects nor builders are going to assume any responsibility as long as the roofer quietly submits to having all the blame put on him or on the tin he uses. The first requirement of a good tin roof is good, smooth sheathing boards upon which to lay it. For this purpose boards of an even thickness and thoroughly seasoned should always be used, for if not dry they will shrink after being laid and so strain and break the seams in the tin. Light or springy boards should not be used, as the seams cannot be pounded down as smoothly as when the boards are solid and firm. Very little pitch is required to discharge all the water that falls on a roof, but architects' and builders' specifications often get so near the danger line that any settling of the building allows the water to stand in pools until it evaporates, and when this is the case trouble is pretty sure to follow, for no roof can be expected to do duty as a reservoir. Any less than ½-in. fall to the foot can hardly be considered safe, while on the other hand any more than 3 in. to the foot is too much to allow the solder being well soaked into the seams. It is of course the work of the car-

penter to provide proper sheathing boards and lay them with a suitable pitch, but it oftens happens that he, through ignorance or indifference, does this work in such manner that the roofer is handicapped in his efforts to put on a roof that will prove satisfactory.

After the carpenter work, the next step to be considered is the quality of tin to be used. In spite of many opinions to the contrary, the high priced, well coated sheets are probably worth as much more than the cheap ones as is asked for them. The cheap tin is made because there is a demand for it, but the roofer who is really desirous of building up a reputation for doing good work will find it to his advantage to use the very best he can prevail on his customers to pay for. The added cost of a good plate is in the coating, and coating means protection to the plate. All this should be pointed out to prospective customers in an effort to get them to pay the difference between a good roof and one that is likely to make trouble. The difference in the cost is all in the tin plate, for it costs no more to put on the best than it does the poorest.

Just as important as the quality of the tin is the size of the sheets used. It would no doubt seem a ridiculous proposition to most members of the trade to-day to advise the use of sheets 10×14 in. in size, but the fact is that using sheets of this size, as they did largely half a century ago, is the principal reason why roofs gave less trouble than they do now. Small sheets are better than large ones for the simple reason that there is less expansion and contraction on each sheet, and consequently less breaking of the seams. The best flat seam roof the writer ever saw was laid with 10×14 sheets. It had been doing good service for over 40 years, and was in good condition as well as smooth and snug to the sheathing boards and without breaks in the seams. But this small size requires considerable time to put on, and for that reason will probably never be popular with the trade and for general work in this line the 14×20 in. size will be used, and if the method of fastening the sheets to the sheathing boards as hereafter described is followed the 14×20 sheets will make a good, serviceable roof. But sheets of a larger size than these should never be used with any expectation of getting good results.

Painting the sheets on the under side was seldom, if ever, done 50 years ago, and is not generally practiced now except in some localities. In some instances it is not necessary, but the idea is a good one, for in the event of a storm coming on before the roof is finished, the sheets already laid are protected on the under side. And even after it is finished leaks are frequently made by accident and not discovered and repaired until some water has found its way through. When this occurs if the tin is protected by paint there is no danger of its being injured. To

judge of the importance of painting the underside, it must be remembered that if moisture once reaches that side of the tin it will begin to rust, and continue to do so until it has eaten through. But if any practical benefit is derived from painting the under side it is necessary to let the paint get dry and hard as well before the work of laying is begun. When the seams are being soldered the paint will be burned just under where the coppers touch the exposed side, but as the solder gives

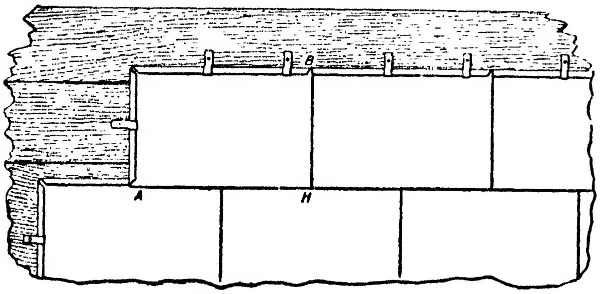


Fig. 25. Sheets Fastened to Roofs with Cleats Properly Placed

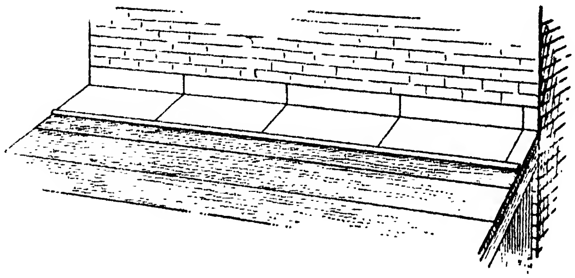


Fig. 26. The Flashing Strip

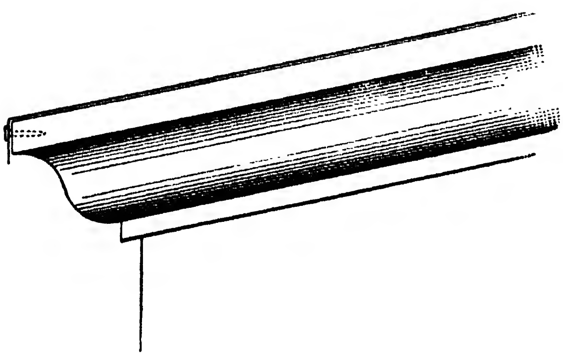


Fig. 27. Finish at the Eaves

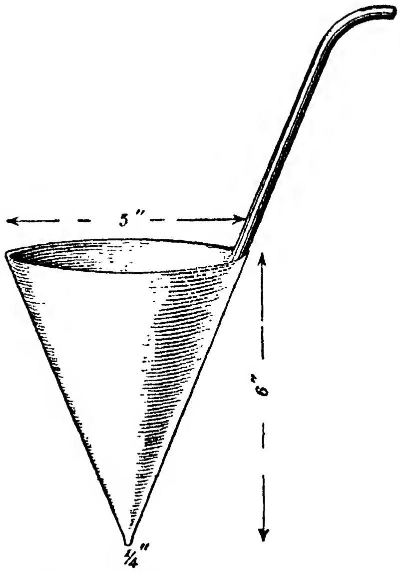


Fig. 28. Rosin Spreader for Seams

an added thickness to the coating it is just there that the paint can be best spared. The expense of painting the sheets is not so great as might be supposed, for it can be done by a boy or other cheap help. The following method will be found both quick and convenient:

Take three narrow strips of wood and nail them on a bench or box of convenient hight, as in Fig. 18, the distance inside the strips to measure 14 in. one way and 20 in the other. Then make a frame of ½-in. stuff and 3 or 4 in. wide, with pieces set in each corner, as shown in Fig. 19; the frame to measure 14×20 in. out-

side. Then after the tin is notched, or clipped at the corners, each sheet can be slipped between the strips on the bench, where it will just fit, and the frame if placed on the sheet inside the strips will enable the painter to paint the whole surface of the sheet except ½ in. on the edge. The sheet after being painted will look like Fig. 20 and not have any paint near enough to the edges to make trouble while soldering.

In making tin ready for the roof it is not necessary as a rule to square the sheets, for if of good quality they are near enough square for all practical purposes in the roofing line. But care should be exercised in notching the corners. As this operation is usually the work of a helper and done with the squaring shear, it is better to have some one more experienced set the machine. Too much clipped off the corner means a waste of time and solder to make tight. The corner looks as shown in Fig. 21 when too much is taken off. It should look as shown in Fig. 22. As it is a difficult matter to cut just enough off each corner without any guide, the use of the device shown in Fig. 23 will be found a great convenience. It is made of tin or sheet iron and can be held in position on the squaring shear by the clamp that belongs with the shear, or if notching is done with the snips it can be tacked on the end of a bench, and while the sheet is held in place with one hand the corner, which will project just the right distance, can be clipped off with the other. As roofing folders do not all turn the same width of edge or lock, it is impossible to state just how much ought to be taken off the corners in every instance, but, as before stated, if the sheet after being folded is as open at the corners and no more so than Fig. 22 it will be found to be about right. It may seem unnecessary to call the attention of any one with any knowledge of the work to a detail so obvious as this, but many who know better make trouble for themselves by neglecting to see that corners are notched as they should be.

In laying flat seam roofing there are two ways of fastening the sheets to the sheathing boards. The one most practiced being that of driving the nails through the sheets just under the lock, is shown in Fig. 24, and it is this practice that causes a lot of trouble with tin roofs, as the solder is not strong enough to hold and leaks around the nails begin the destruction of the roof. In laying metal roofs it must be borne in mind that the expansion and contraction are due to a natural law that no one can prevent being enforced, but if the sheets are fastened in such a manner as to allow the metal to expand and contract without breaking the seams, then the trouble from this source is overcome.

The method of fastening the sheets with cleats is shown in Fig. 25. It holds the sheets firmly and yet yields enough during changes of temperature to prevent

the breaking of seams, and even should a break occur, there is no nail hole in the sheet to let water through, as is the case where nails are driven through the sheets. These cleats should be cut about 2 in. long and 1 in. wide. As they can be cut in the squaring shear and the lock turned on them in the shop folder by a boy or helper, their cost is very little, especially as they can be made of odds and ends of scrap tin that would otherwise be wasted.

The use of cleats in laying flat seam roofs is well understood and practiced in some sections of the country, but in others it is not customary to use them. Of course it takes longer to lay sheets when fastened this way, but it is time well invested. The usual practice of laying sheets singly is the most satisfactory except where the tin has to be turned up against another building or a side wall. In a case of this kind it is better to get out a strip the right length and after soldering to turn up as much as is needed, leaving a lock on the surface of the roof to be hooked on to, as shown in Fig. 26.

In laying the first course care should be taken to leave enough projecting over the edge so that when turned down and nailed the tin will extend below the nailing strip and so cause a drip to form at the eaves, as shown in Fig. 27. If this is not done the water will run down the molding and discolor it, and besides a gutter hung under the eaves will be of no use if the water follows the woodwork after leaving the tin.

To insure well locked seams it is necessary to keep the edges of each course straight, and it will be easier to lock the sheets well if after one is laid the seam at the point A and the point B in Fig. 25 is flattened down with a stroke of the hammer before laying the next one. Three cleats are enough for each sheet if placed as shown in Fig. 25.

It is advisable not to lay any more tin than can be soldered each day, but if for any reason it is thought best to lay more it is better not to mallet it down, for it will be just as near tight and if rain falls on it the seams will dry much quicker than if flattened down. Seams that are malleted down smooth are easier to solder and hold better than when uneven.

Rosin makes the most satisfactory flux, and the most convenient way to apply it is to melt it on the seams with the aid of a home-made funnel of about the dimensions given in Fig. 28. In soldering off a roof it is well to use as large coppers as the pitch of the roof will permit, for small coppers both heat and chill too quickly for satisfactory work. If too hot the coating is injured, and if too cold the solder is not sweated into the seams as it should be. For a roof of ordinary pitch or fairly flat, coppers weighing 8 or 9 pounds to the pair should be used, but

if the roof has a pitch of 2 in. or more to the foot, lighter ones can be used to better advantage.

The long seams on the roof should be soldered first, and before the rosin is run on the short ones the butt of each seam (see H in Fig. 25) should be tapped down smooth. It pays to use good half and half solder, not only because it makes a better job, but because it flows more freely and so saves both time and solder. If the roofer really wants to do good work in this line he must be willing to take or pay for the necessary time to do it. It is hardly an exaggeration to say that the foolish practice of trying to make or break a record while doing this work is responsible, for as many poor roofs as is poor tin.

PRACTICAL TALKS ON TIN ROOFING—II

To knock out strips in the shop the work can best be done on a special bench about 20 feet or more in length, made of 2-inch or thicker yellow pine or other hard wood planed smooth on the top side. The bench should be 30 inches wide, with a pitch of 1 inch down to the front, so that solder will flow readily. It should be well supported, and some benches are made with iron plates 3 inches wide and ½ inch thick where the locked edges come to stand the wear of the mallet. The back edge must be perfectly straight from end to end, with a hard wood gauge about 3 inches high extending the whole length. This edge may be faced with metal to prevent wear and preserve its trueness as a straight edge.

After the sheets have been edged, with one edge turned up and the other down, a number may be spread along the bench to have their edges locked together to form a continuous strip. This is best done by locking one pair of edges at a time. The first sheet must be held firmly against the straight edge by a gauge fastened to the bench or by a double hook, one end of which catches the sheet and the other catching over the back of the bench. Some men nail the first sheet to the bench with two roofing nails. The other sheets may then be locked on one at a time and have the seam flattened down tight with a mallet, great care being taken to see that the side of each sheet is perfectly in line against the straight edge guard at the back of the bench. A box of tin contains 112 sheets, and in some shops they are put together in four rolls of 28 sheets each and the rolls when soldered weigh about 60 pounds. The seams may be soldered as soon as the locked edges of one strip are flattened down with the mallet and before rolling up, or the roll may be completed and several boxes of tin may be put together and the soldering done at another time.

In soldering an old hand will want coppers weighing eight pounds to the pair, powdered rosin, good solder and a fire pot large enough to heat the coppers quickly. Experienced men are very careful to leave a space ¼ inch unsoldered or very lightly soldered at each end of the seam. This will make it easier to turn the edges and make the locks on the roof. The strips are generally 20 inches wide and 20×28 inch tin is used, owing to there being fewer seams to be soldered than if 14×20 inch tin is used. If 10-inch strips are needed for valleys or flashings it is only necessary to slit the 20-inch tin down the middle. If 14-inch strips are wanted labor is saved by putting the tin together in 28-inch rolls and slitting it down the middle. After the soldering is done the tin is ready to be painted on the under side, if the contract demands it, but in painting a space ½ to ¾ inch wide should be left along each edge, so that no oil or burned paint will interfere with soldering on the roof.

The rolls when finished are about a foot in diameter, and the end is fastened to the roll by tacking with solder lightly so that it can be easily opened with the roofing hammer, or the rolls may be fastened with wire or tin strips.

If the strips are for flat seam roofing, half-inch tongs are used to turn half-inch edges on the strips. The tongs have jaws about 20 inches long, with holes in one jaw and curved pins about 2 inches long in the other jaw which work through the holes, and they are set so that the edge turned on the tin is just ½ inch wide. In laying the tin the first strip is laid at and parallel with the eave and extends over so that is can be turned down and fastened with 1-inch barbed roofing nails about 2 or 3 inches apart. The ½-inch edge is turned on the other edge of the strip, which is fastened to the roof with barbed roofing nails about 4 inches apart, for the closer the nails the easier and quicker it is soldered and the less solder required. The nails must be driven back in under the edge, so that when the edge of another sheet is hooked in and flattened down tight with a mallet the nail heads will be covered. If tinned nails are used the soldering will be more secure. By this method there are no nails in the cross seams, and in consequence some roofers use strips only 14 inches wide, while others use 20-inch strips for all such work.

The soldering should be done with heavy coppers with blunt ends, so they will hold the heat, and the seams should be well soaked with a hot copper so that the solder will sweat into the locks and make the seams surely tight, for any time spent in hunting for and mending leaks is a dead loss, even if no damage is done to the building. For flat seam roofing a sheet at a time the sheets are notched, edged and stacked in lots of 11 sheets for 14×20 tin, and 25 sheets for 10×14 tin. The tin now being ready for use at the building, it will be convenient to provide a box,

say 12×16 inches in size and about 4 inches high, made with three compartments and with a circular handle over it. One-inch wire nails, $2\frac{1}{2}$-inch wall hooks and rosin are placed in these compartments. The tools required are eight pound soldering coppers for roofing, as shown in Fig. 29, and six pound pointing up coppers, as shown in Fig. 30; a file, a hammer, shears, a compass, a punch, a cold chisel, a mallet, a scraper, a trowel, and chalk and chalk line. A fire pot 15 inches high and 8 inches in diameter is required for the roofing coppers, a smaller pot 12 inches high and 6 inches in diameter is large enough for the pointing coppers and will consume less coal. Solder, coal, acid for galvanized iron connections, a paint brush, and paintskin, an iron block on which to forge coppers, a rope and wheel to hoist material, a broom, and a small tool box with lock and key to lock up tools and material over night, constitute all that would be required for work on the roof.

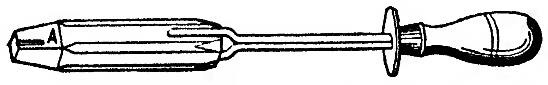


Fig. 29. Square End Roofing Copper

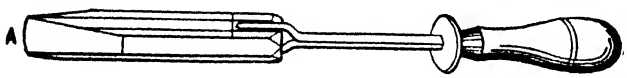


Fig. 30. Pointing Up Copper

The heavy soldering coppers are used for flat seam soldering and the lighter ones to do "pointing up," or soldering upright seams. The file is employed to clean and smooth the coppers. The coppers are tinned with rosin when used for soldering tin work, using rosin as a flux. They are tinned with sal ammoniac for soldering zinc or galvanized iron work, when acid is used as a flux. The hammer and shears are used in laying the tin, the compass for scribing circles or for other purposes. The punch is employed to make holes in double thicknesses of metal, the cold chisel to dig out joints for flashings, the mallet to flatten the seams, the scraper to obtain a smooth, clean surface on old metal joining to new work, and the trowel to paintskin the joints of the flashings connecting with the walls. In starting a small shed roof, Fig. 31, which has no gutter, the water dripping off at A, the tin B is laid sheet by sheet, allowing it to project over the eave about 1 inch, as at A. It is finished at the top, as shown by the last course C, which also projects at D; then with a piece of plank measuring about 4×8 inches and 1 inch in thickness the edges are dressed down well with a mallet,

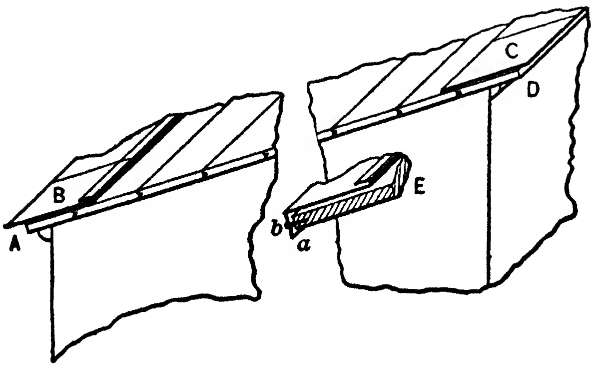


Fig. 31. Starting and Finishing a Shed Roof

as shown in diagram E at *a*, after which it is nailed, as shown at *b*, with 1-inch roofing nails. A mistake which is often made is in dressing the edges with a mallet. This causes the edge to lose its straight line and to show a succession of

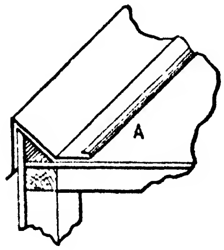


Fig. 32.
Side Strip on a Shed Roof

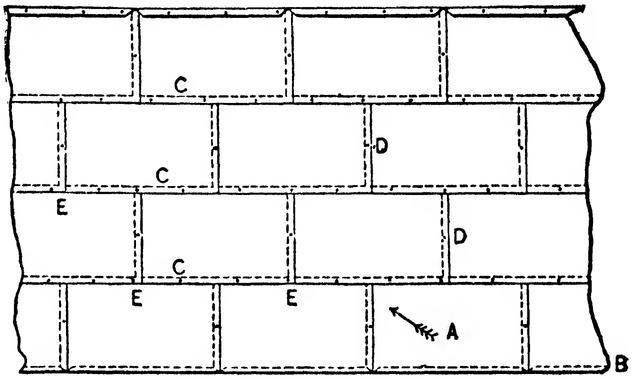


Fig. 33. Laying and Nailing the Sheet

buckles. Occasionally on a shed roof, or other roof of frame buildings, a ledge is built on the gable or side walls, as in Fig. 32. This is the proper form to throw off the water well and avoid acute angles. These strips are put on before the roof is started, having a lock at A, and being turned over the clapboarding or other surface with a drip, as at B. Assuming that the roof is to be covered with 14×20 plate, the sheets are laid as indicated in Fig. 33, the general rule being to lay the sheets in the direction of the arrow A, giving four nails to the sheet; one at the butt, two on the long side and one on the short side, as shown by the dots. This will make

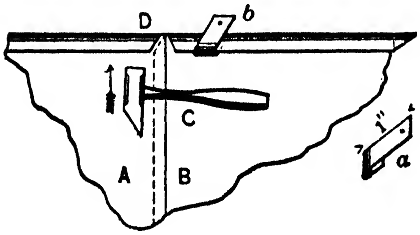


Fig. 34. Driving Edge Back to Place Nail

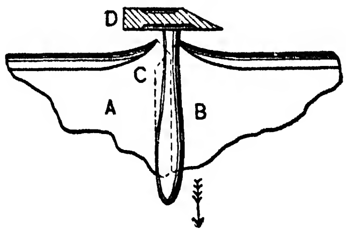


Fig. 35. Replacing Edge

a firm roof, and hold the seams well. If less than four nails are used the tin is apt to buckle, causing a drumming sound when it is walked upon.

While time is saved in the laying, double this time is lost in soldering, for the heat of the coppers will raise the seams, causing a succession of buckles which retard soldering and require 10 per cent. more solder. In laying the sheets the hammer is used, as indicated in Fig. 34, A being the sheet locked into the sheet B. The hammer is held in the position C, and is quickly moved forward in the direction indicated by the arrow, both on sheets A and B. The nail C is now driven into the sheet A at the butt, which holds down the sheets A and B firmly; the hammer is now placed as shown in Fig. 35, and held in the position D, the handle inclined slightly upward. It is then pressed down and drawn quickly forward, which again brings the edge in the position D, as in Fig. 34. The same directions apply to the nailings in the centers of the sheets. If cleats are required instead of nails they are bent as shown, at *a*, Fig. 34, and hooked to sheet as *b*. This is not the proper location of cleat for they should be placed where the nails are shown in Fig. 33. Care should be taken to flatten seams well with a heavy mallet whose face has been rasped to a convex surface, as Fig. 36. A mallet, as Fig. 37, should not be employed, as is often the case, for it will not close the seams evenly. If it is not a windy day the rosin can be ground to a powder and swept against the seams with a clean broom; or the rosin can be melted on the seams by taking a soldering copper which is sufficiently heated to melt the rosin and running the copper along the seam and against the copper, holding a large lump of rosin. As previously shown, soldering coppers for the flat seams are blunt on the ends and are tinned on two sides only.

Fig. 36. Smooth Round Faced Mallet

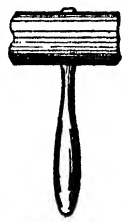


Fig. 37. A Bad Mallet for Roofing

Some mechanics file a groove A in the copper as indicated by Fig. 38, about ¼-in. from the corner so that when the copper is drawn along the seam this groove acts as a guide and keeps the greater part of the copper B, on the seam, soaking in the solder. When soldering a long surface, all the long seams, indicated by C, C, and C in Fig. 33, are first soldered, then the short seams, indicated by D and D. After this the "butts" E E E are gone over to prevent any leak.

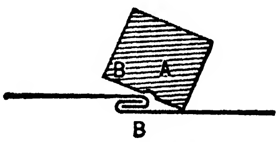


Fig. 38. Soldering Copper with Groove for Guide

Another sheet, edged on the flat seam edger, is illustrated by Fig. 39, and is known as a valley sheet, having the edges A and B turned one way, while the short sides C and D are edged right and left. In some cases where required the short sides C and D are edged one way and the opposite sides A and B right and left. The use of valley sheets is shown in Fig. 40. A roof on which the water

pitches towards the center is shown by A, and the tin is laid from both sides, or perhaps one side is worked up to the valley sheet and the edge peened into the edge of valley sheet. Oftentimes a strip is "knocked" out for valleys, same as for flashings, instead of laying sheet by sheet and a bend made with a plank, as described later for gutter lining. In Fig. 41 is shown how a box gutter made of wood is lined with

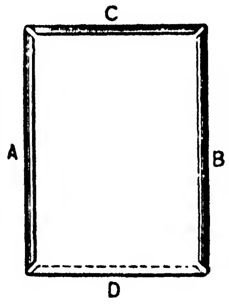


Fig. 39.
A Valley Sheet

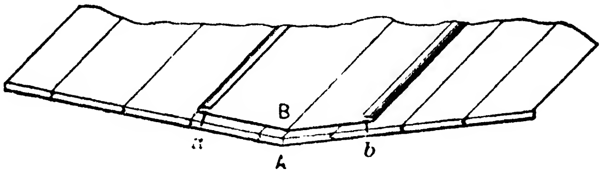


Fig. 40. Laying a Valley

tin. The method which will be described for bending up the tin strips will also apply to the bending of wall and curb flashings, etc. Therefore let A represent the wooden gutter and B the tin lining in place, projecting over the wood molding at C and having a lock on the roof surface at D. When the gutter is in place the tin

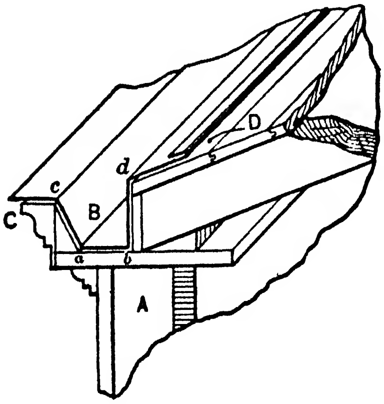


Fig. 41.
Lining a Box Gutter

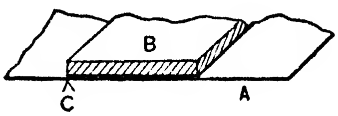


Fig. 42.
First Operation Bending Strips

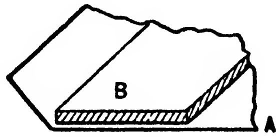


Fig. 43.
Second Operation Bending Strips

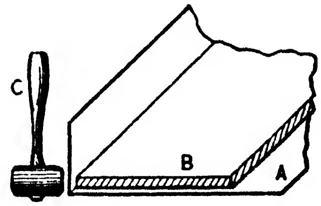


Fig. 44.
Last Operation of Bending the Strip

is turned over at C and nailed, in the same manner as shown by *a b* in E, Fig. 31. Assuming that the gutter is 20 feet long, in Fig. 41, "knock out" 10 feet of tin strips of the required width, being careful to have a straight line; this is most readily accomplished by tacking the first sheet with nails, then following the chalk line or such other line as may be employed, and lock by means of a mallet the required number of sheets.

The short seams are soldered, then the bending is done as shown by the three operations in Figs. 42, 43 and 44, first striking chalk lines where the bends will be; a blue chalk shows better on the tin than white chalk. In Fig. 42, A represents

the tin strip and B an ordinary roof plank having a straight edge; C indicates the first bend which is to be made. Now take the board, lay it at the required line, C, and while standing upon it with the legs slightly spread, stoop down with arms stretched, grasp the tin firmly and bend it slightly upward. Then it will appear as shown in Fig. 43. Now grasp the tin again and in the same manner, and bring it over to a right angle, after which use the mallet, as shown in Fig. 44, and dress it well against the board. This will complete the last operation in bending the strip. It should be understood that these operations are for the two bends *a* and *b* of Fig. 41 only, and that the other bends are made when the lining is in place by laying a board in the gutter and standing on this so as to keep the lining well down in the gutter, then with a mallet and board dress the tin over on the roof and over the front of the gutter; turning the seam edge on the roof with tongs.

Connecting roof to wall flashings, etc., will now be taken up. The methods given are strictly correct, therefore a few remarks relative to reversing seams in roofing will not be amiss, and it is believed that it is of sufficient importance to reprint here the substance of the remarks relative to the question of having seams against the water.

It is agreed that whenever practical the seams in all types of roofing should be so as to shed water, and that you invite trouble when you have seams the other way, for no matter how strong you solder a seam there is always a likelihood of seam opening, and water would then run into seam, whereas if correctly made it would flow over the open seam.

It is conceded, though, that it is often necessary to have seams reversed. To illustrate—if we have a roof with a gutter and fire, or battlement, walls on the other three sides we would first (after setting gutter) "knock out" flashing strips for these three sides. These strips are nailed in place with the edge turned up. Then when laying the sheets we work from the strip on one side to the other and peen the edge of sheet into the flashing; likewise at the top strip the last course of sheets are peened into the strip making a seam against the water. And this method is employed in a good many other cases, around chimneys, etc. The correct methods will now be discussed.

Fig. 45 shows an extension roof which butts against the main building, whose walls are frame. Assuming that the last course of tin is in the position shown, take the distance from lock A to the wall B, bend off the strip as has been explained, being careful that the tin goes high enough to lap at least 4 inches under the clapboard D. If the clapboard is fast it should be loosened to allow tin to go under,

and not nailed, as is frequently done, on to the board D and then paintskinned. This will eventually cause a leak. If this main wall were of brick or stone the tin would be let into the joints, as indicated in Fig. 46. This engraving represents a side strip on a flat roof with lock attached, to lay on the roofing. A shows the brick wall and B the tin strip, having a 1-inch edge turned into the joint, then wall hooked and paintskinned. It is usual to turn up side strips to the fourth course of brick over the finished roof. When building the wall it is customary for the masons to clean out the mortar where the tin is to turn in the wall. Should they fail to do this, then the first thing to do before laying the roofing is to dig out this joint with a hammer and chisel or an old saw. Fig. 47 shows a cap and base flashing, which allows for expansion and contraction of the metal. When the wall has been carried up to the required hight, or four courses above the finished line of

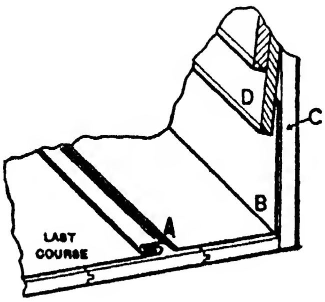


Fig. 45.
Flashing under Clapboarding

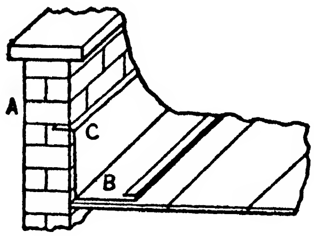


Fig. 46.
Side Strip Inserted to Connect Roof with Wall

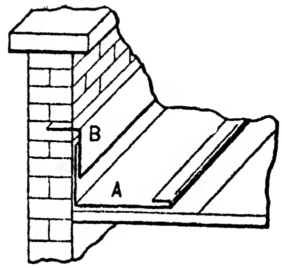


Fig. 47.
A Cap and Base Flashing to Allow Expansion and Contraction

the roof, the cap flashing B is placed in position, as shown, after which the mason completes the wall and sets the coping. The base flashing A, having a lock as indicated, is turned up under the cap B to within ½ inch of the top of the cap flashing.

It often occurs that a skylight or scuttle is placed in a roof, the curb of which must be flashed and the corners double seamed, as shown in Fig. 48, A representing the scuttle opening and B C D E the curb, the water running in the direction of the arrow. Then the corners should be double seamed, as shown in diagram F, and the locks made so that when closed, as at *a*, the water coming in the direction of the arrow H, will pass over the seam. If the seams were made in the opposite manner the water would run into the joints. This shows how to seam the corners and flash around a curb or bulkhead or any other structure on a roof. The method of obtaining the correct seam lines on the front, sides and back is shown in Fig. 49, and is applicable to curbs, scuttles, chimneys, etc. A B C D represents a

bulkhead over a roof around which flashing must be placed, the sides and top to be covered with tin. E represents the last course of tin, which is laid before reaching the bulkhead. To put in the strip F G, assuming that the distance from the lock to the bulkhead indicated by F is 10 inches, bend off 10 inches on the strip, as shown in Fig. 42, making the distance of G in Fig. 49, 4 inches, using 14 × 20 inch tin. When the strip is bent up it is notched at the corners to allow for double seaming, as shown at F in Fig. 48, notching the corners, Fig. 49, so that the portion H forms

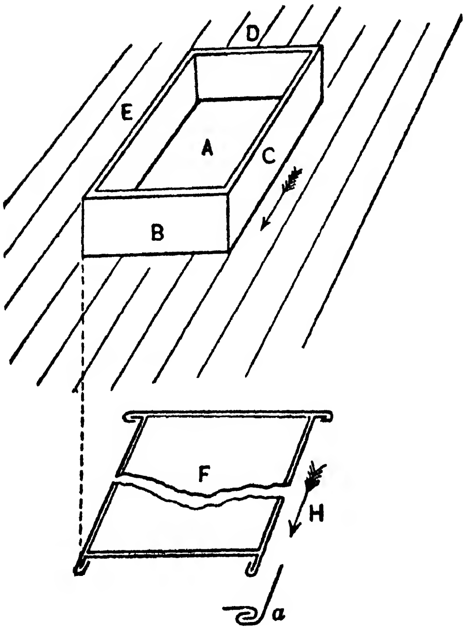


Fig. 48. Double Seaming Corners

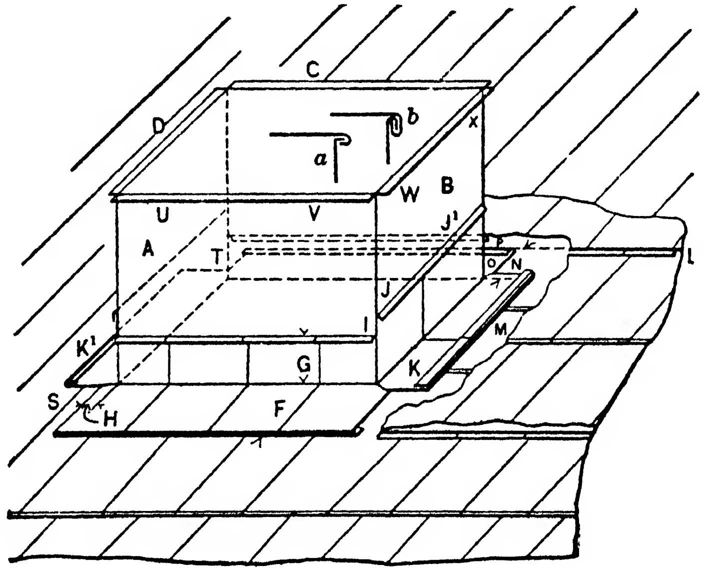


Fig. 49. Flashing Around a Structure on a Roof

a lap on the roof, and to be pieced out later. The side strips K and K¹ are now put in position, care being taken that the lock J of the side strip K runs above and breaks joints with the lock I of the front strip F G.

The tin roof is now continued up to L, or the first seam above the bulkhead, the flat portion at M being broken in the diagram to better illustrate the locks. The line of the seam L is now extended with pencil, as shown by the dotted line, so that the proper measurement of the distance from the bulkhead to the lock L can be obtained, as at N. Bend off the rear strip O so that the lock P will be in line with the lock L, exercising care that the lock J¹ on the strip turned up against the bulkhead will break joints with the lock J on the side strips. The roofing is now continued from the locks L P, after which the corners N R S T are pieced out and soldered.

The sides of the bulkhead are tinned up in the usual manner, allowing edges for double seaming at the corners, and allowing a single edge at the top, as indicated by U V W X C D, Fig. 49. Then, when covering the top of the bulkhead, the roof is locked into the single edges U V W X C and D, as shown at *a*, and is then turned over to form a double lock, as at *b*. The corners are now double seamed, soldering the lower part 6 inches above the roof line, while the balance of the seams at the corners and sides are painted with a thick coat of red lead. After this they are flattened or closed with the mallet, which insures a tight joint.

We will now consider the soldering of upright seams, which becomes necessary when cross seams occur in side or wall flashings or when the corners of curbs or chimneys have to be soldered. Fig. 50 illustrates a cross seam in a side wall flashing, A B indicating the metal flashings fastened to the wall joint by the wall hooks *a*, *b* and *c*. The seam being properly locked and closed, it should be soldered in the following manner: First, prepare or forge the soldering coppers, as in Fig. 30; the front A is wedge shaped, ¼ inch thick by about 1¼ inches wide, and is used for upright seam work. This style of soldering coppers should be tinned on one side and on the end only; if tinned otherwise the solder, instead of remaining on the tinned side, would flow downward; by tinning the copper on one side only the remaining sides will be black and will not tend to draw the solder downward. The soldering copper being thus prepared, solder the upright seams in the manner indicated in Fig. 50, holding the copper in the position shown by C. This allows the solder to flow forward, while if the copper were held as shown by the dotted line D, the solder would flow backward and away from the seam. First the seams are tacked, in order that they will lie close; then the seam is thoroughly soaked with solder, after which ridges of solder are placed across to strengthen it. In "soaking" the seam the copper should be placed directly over the lapped part, so that the metal is thoroughly heated. This enables the solder to flow between the seams of the metal, making a tight joint. The same method applies to any other upright seam.

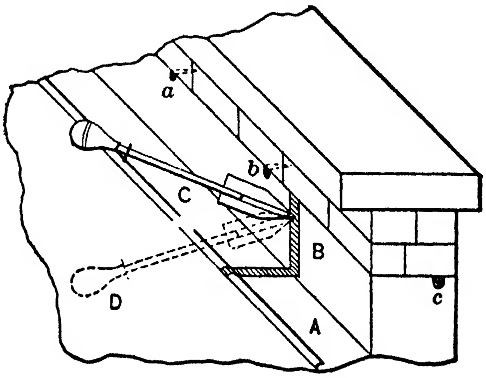


Fig. 50.
Soldering Upright Seam

PRACTICAL TALKS ON TIN ROOFING—III

We will now give attention to the method of laying standing seam roofing, in which the cross horizontal seams are locked as in flat seam roofing and whose vertical seams are standing and locked, as will be described in connection with Figs. 53 and 54. Assuming that the pitch of the roof is 18 feet long, the tin is edged on the 14-inch side only, right and left, and as many sheets are locked together as are required for the 18-foot pitch. Some men prefer to "knock out" long strips and cut off as much as needed.

After the necessary number of strips have been locked and soldered, the standing seams are bent up with the tongs, or, what is better and quicker, the roofing edger for standing seam roofing. This is a machine into which the strips of tin are fed, being discharged in bent up form as required and as shown in Fig. 51, 1 inch on the one side and 1¼ inches on the other, or they can be bent 1¼ inches on the one side and 1½ inches on the other, as is most desirable. This gives a ¾ inch finished seam in the first case and 1 inch in the second when completed.

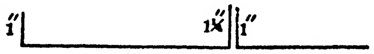


Fig. 51. Edged Strips Laid for Lock Seam

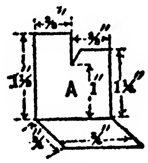


Fig. 52. Cleat for Fastening Strips to Roof

In laying the strips they are fastened by means of cleats, shown in Fig. 52, with full size measurements. These cleats allow for expansion and contraction of the metal, and are applied as shown in Fig. 53, which also shows the first operation in applying standing lock roofing. Some roofers use cleats which are not notched out, as is indicated at A in Fig. 52, but cut the cleat square at the top, and instead of turning the cleat right and left, as in Fig. 53, they only turn the cleat over the strip B, the strip C not being secured until the second operation is performed, as in Fig. 54. However, by turning the cleat as shown in Fig. 53 both sides of the strips are held down and trouble from the wind is avoided.

Assuming that all the strips have been bent up 1 and 1¼ inches, apply them to the roof boards as follows: Let A represent the hanging gutter at the eave of the pitch roof, having a lock bent on it, as at D. Take a strip of tin, B, having a lock at the bottom, as at E E, and lock it well in the lock of the gutter, as shown. Then with a cleat made of scrap tin, Fig. 52, place it as indicated in Fig. 53 by F. Lay it tight against the upright bend of the strip B and fasten it with a roofing nail at *d*. Now turn the edge of the cleat F over the tin strip, as shown at *a*; this holds the strip B in position. It is usual to place these cleats about 20 inches

apart, and in some cases they are placed closer, as desired; sometimes two cleats to a 28-inch sheet. The next strip, C, should have a 1-inch bend. Lay it tight against the $1\frac{1}{4}$-inch bend of the strip B, lock it well into the lock D of the gutter, press it down well at the corner of the roof, and turn over the edge of the cleat, as

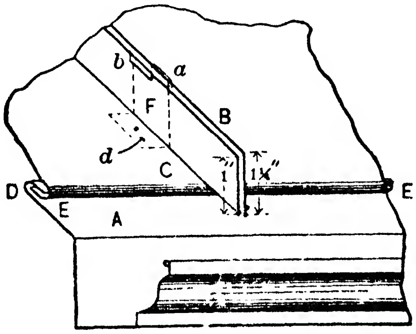


Fig. 53. First Operation

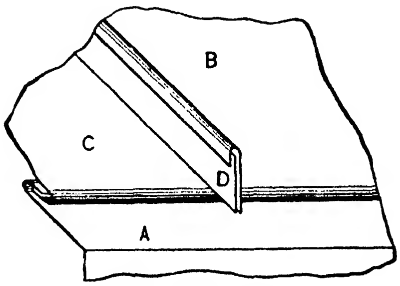


Fig. 54. Second Operation

at *b*. This holds the strip C in position. It will be noted that no nails have been driven into the standing seam strip, the entire roof depending on the cleats to hold it down and prevent rattling.

The next operation is shown in Fig. 54. By means of the hand seamer and mallet, or with the roofing double seamers, the first or single seam is turned over, as shown at D. If the hand seamer is used it is held in the left hand and the single edge is turned over with the mallet. Roofing double seamers are widely used, and two constitute a set to finish a seam. One of the seamers does the bending and the other the squeezing. Both can be made adjustable for the first or single seam and for the double seam. The operations are performed by the foot treadle, the handles being used to clamp the edges. Much time is saved in the use of the double seamers over that expended in the use of the hand seamers.

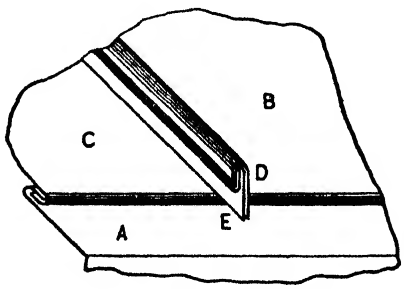


Fig. 55. Last Operation

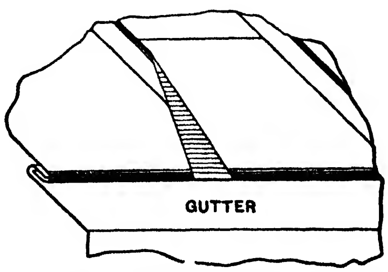


Fig. 56. Finishing a Standing Seam Roof at Gutter

When the seam D has been tightly closed the double seam is made, as shown at D in Fig. 55, involving the same operations with both the hand and roofing seamers. This is explained in connection with Fig. 54.

If desired the seam E, in Fig. 55, can be soldered, but this is unnecessary on a steep roof, as the water will not back into the seam. While the three operations shown in the three preceding figures indicate the method of double seaming, another method of locking the standing seam roof into the gutter edge is shown in Fig. 56, in which the standing seam is flattened and locked into the gutter, as shown.

Fig. 57 illustrates a roof starting at the eave and having a hanging gutter and gable wall flashing. A indicates the gutter flanged to the roof, as shown at B, allowing the flange B to extend under the side flashing F, as at C. At the front of the parapet wall notch out the flange of the gutter, and bend it up against the wall, as indicated by the dotted line D. When the gutter is in position and the gutter braces fastened to it the side wall or step flashing E F G is put in position, stepping double courses of brick, as shown, and flanging into the joints of the brick work or other wall and fastened with wall hooks and paintskins, and overlapping the gutter flange D. as at H.

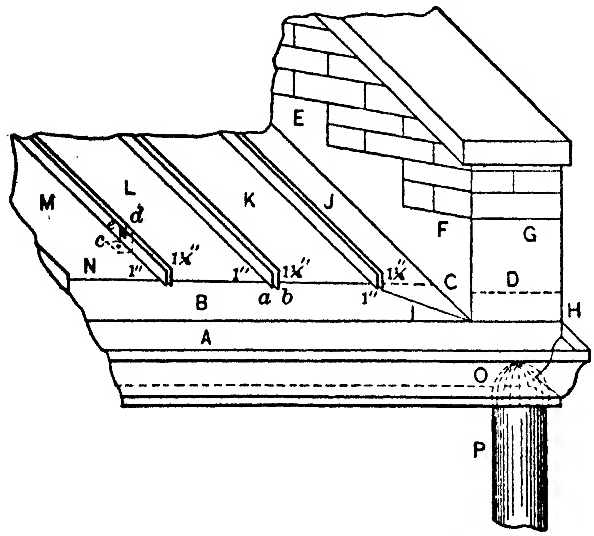


Fig. 57. Standing Seam Roofing, Laying the Strips

The strip is flanged outward on the roof, as shown at J, Fig. 57, about 7 inches, or as much as the width of the tin strip will allow, and on this strip the 1¼-inch bend is made, mitering the flange J over the flange B of the gutter, as shown at I. The strips K L M are now placed in the positions indicated, using the cleat N, as in Fig. 53, and also shown by *c d e* in Fig. 57. Care should be taken to lock the strips well at the bottom into the lock of the gutter flange B, as is indicated by *a b*. O is the wire strainer or basket placed over the leader P. The entire roof is finished in the manner indicated, when the double seaming is done, as previously explained.

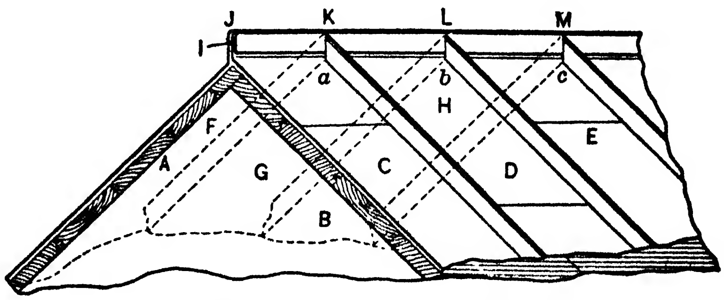


Fig. 58. Finishing with a Comb Ridge

Fig. 58 illustrates a finish made at the ridge of a standing seam roof. This is known as a comb ridge. A B indicates a section of the roof boards, C D and E are strips of tin having a single edge at the ridge, as shown by I, while the opposite strips F G and H have a double edge at the ridge, as at J. The standing seams K L M are mitered and are soldered from K to *a*, L to *b* and M to *c*. When the comb ridge is not required it can be double seamed, as at A in Fig. 59, leaving the standing seam miter at B C and D, and soldering from B to *b*, C to *c* and D to *d*.

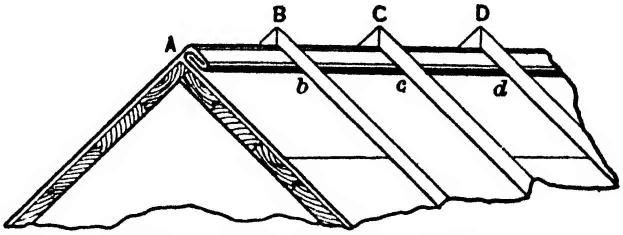


Fig. 59. Double Seaming the Ridge

When mitering the standing seams at the top it is better and quicker to make a small "gauge" with which to mark each strip at the top after the standing seams are turned up. This "gauge," or shape, can be made as follows: In Fig. 60, A represents a piece of the tin strip in use before being bent up and about 12 inches long. Obtain the angle of the roof at the ridge, as in diagram B C. Parallel to C and B measure off a distance of 1¼ inches and draw the lines D E and E F; then draw a line from E to H, after which take a tracing of H E F J, to be placed as shown by L M K; repeat the operation at N. Allow for the vertical seam O, as shown. The dotted line P indicates the allowance for the double seam. Then all the tin strips for one side of the roof should be cut without laps, as shown by L M O N. The tin strips for the opposite side should have laps for seaming, as in Fig. 61. This figure exhibits the top of the strip bent up

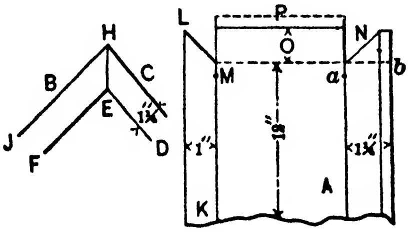


Fig. 60.
Gauge for Cutting End of Strip to Fit Comb

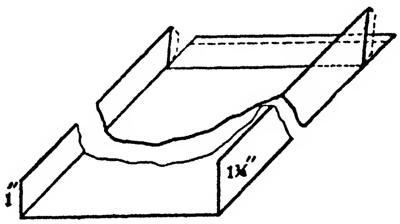


Fig. 61.
Roofing Strip Cut to Fit Comb

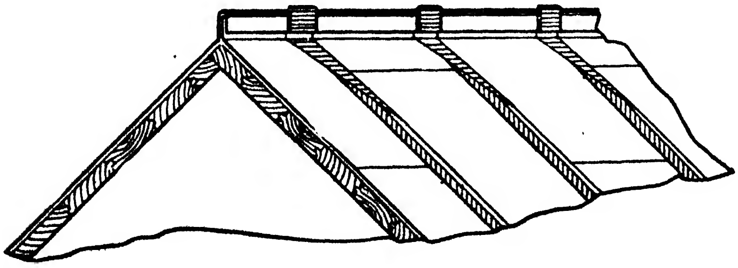


Fig. 62. Ridge Comb Finished with Standing Seam

and having laps. In Fig. 62 is shown another form of comb ridge, in which the standing seams are flattened and then turned up the same as in standing seam work, by means of tongs, and double seamed with the hand seamer, as shown in the illustration. Fig. 63 shows the method of finishing the standing seam when it butts against the wall and it is desired to put in a flashing. In this case proceed as follows: A represents the roof boards, B and C tin strips put in position, and having a lock as at E and D, the distance from the wall to the lock being as desired. It will be noticed that the standing seam H is turned over by means of a mallet, as shown at J, after which the flashing F G is locked into it, as at K. Then the seam K is tightly closed with the mallet and the seam K H soldered. If the roof is steep the soldering is not necessary. The top of the flashing is flashed into the wall and fastened with wall hooks, *a b c* and *d*, and is then paintskinned or cemented.

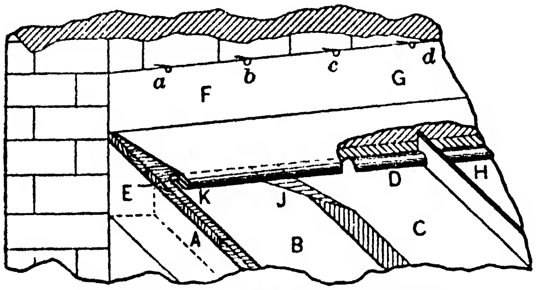


Fig. 63. Flashing Against a Wall

The method of turning over the double standing seam H, as shown at J, is sometimes employed where the seams meet at the ridge, as at B C and D in Fig. 59. Then they should be cut square, as at *a b* in Fig. 60, and turned over, as shown by J in Fig. 63. Double seam and solder at the ridge, as at A in Fig. 59.

It is not out of place here to remark that for a tile roof that abuts a gable wall as in Fig. 57, the flashing would be bent and put in as the strip J. Though most likely it would be bent up straight, with the wall and roof and covered with a cap flashing, E F, still giving the same appearance as Fig. 57.

PRACTICAL TALKS ON TIN ROOFING—IV

There is a question with some roofers as to whether it is best to use a revolving roofing edger in preference to ordinary roofing tongs in turning up edges for standing seams. While it is true that the revolving edger is very much more rapid than tongs, so far as turning out edged courses goes, careless use of the edger will leave the tin in such shape that the extra time consumed in doing the double seaming goes far to offset any gain over tonging. If the edger is not firmly secured to the roof and the tin passed perfectly straight through it the result will be much

variation in the width of the edges turned up. It is a common practice when putting on roofing requiring long courses for one man to start one end of a roll of tin through the edger located at the high point of the roof, and for another man to take hold of the tin as it emerges from the edger and draw it through rapidly instead of winding it through by turning the handle. In pulling the tin through in this manner the operator is almost certain not to walk straight down the roof, or the machine may slip a little so as to cause feeding of the strip too much to one side of the machine. If the pressure favors the wide edge side, the result will be too much tin to fold into the double seam on that side, as indicated at *a*, Fig. 64, and too little tin on the other to stand up high enough to be folded into the double seam, as indicated at *b*. If the pressure favors the narrow edge side the result will be too little tin on the wide edge side to double seam, as indicated at *c*, and so much on the narrow edge side as to necessitate triple seaming, as indicated at *d*, which adds unnecessarily to the labor of double seaming. A course of tin thus improperly edged is indicated in Fig. 65, and it will be seen that the edges not only vary in width but the course is made slightly crooked.

In edging tin with a revolving edger, the machine should be firmly secured on a portable base, and this base should be provided with forked standards for carrying the axle, which in turn carries the roll of tin which is being run through the machine. Fig. 66 gives an idea of this arrangement. The tin should be started through the machine and the lower end slightly turned up as indicated, so that it will slide down the roof without catching against the edges of boards, etc., and it should be forced through by turning the handle of the machine. The tin should not be pulled through independently of the handle. Care should also be taken to see that the axis of the rolls is exactly paralled with the ridge, or perpendicular to the rafters of the roof, so that the weight of the course after it has been passed through the machine for some distance will not tend to pull the tin one sided. The uprights *a* should not be located so as to interfere with a true entrance of the tin into the machine.

If the revolving edger is worked in this manner fairly reliable results can be depended upon as regards width of edge, but experience has shown that the average roofer is not content to grind the tin through the machine in this comparatively slow manner, when he can take hold of it and pull it through on a run, though he is almost certain to hamper the double seaming operation and cause badly finished work in the end. While even the grinding through method in using the revolving edger is considerably quicker than tong work, there still remains a slight disadvantage, in the stretching of the tin, which causes the standing edge to be somewhat

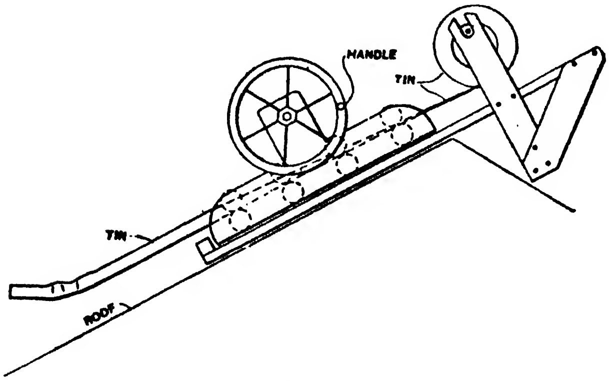


Fig. 66

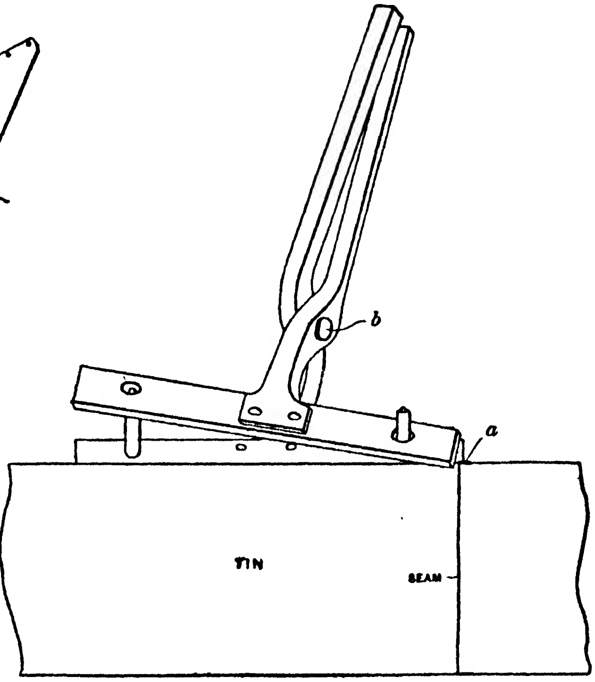


Fig. 69

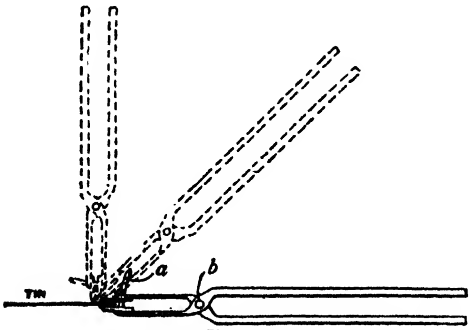


Fig. 68

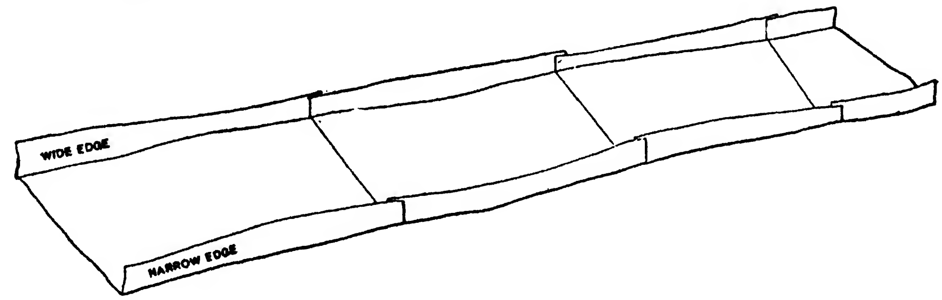


Fig. 65

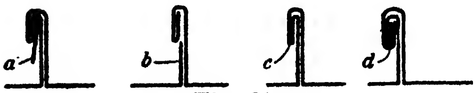


Fig. 64

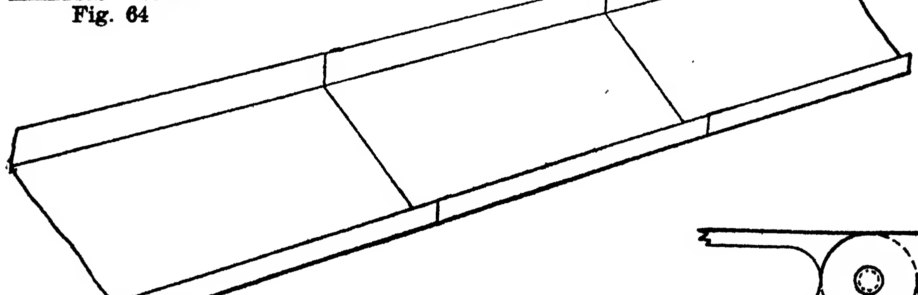


Fig. 67

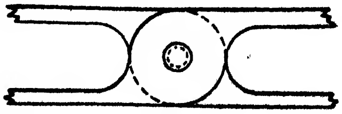


Fig. 70

PRACTICAL METHODS OF LAYING STANDING SEAM TIN ROOFING

buckled or wavy, making the first operation of the double seaming comparatively difficult.

Fig. 67 shows a course of tin as it appears when edged up with roofing tongs. Fig. 68 shows how the tongs grasp the edge, and it will be seen that the width of edge turned is entirely governed by the gauges *a* and the method of operation is such that varying widths of edge are not likely obtained. These roofing tongs

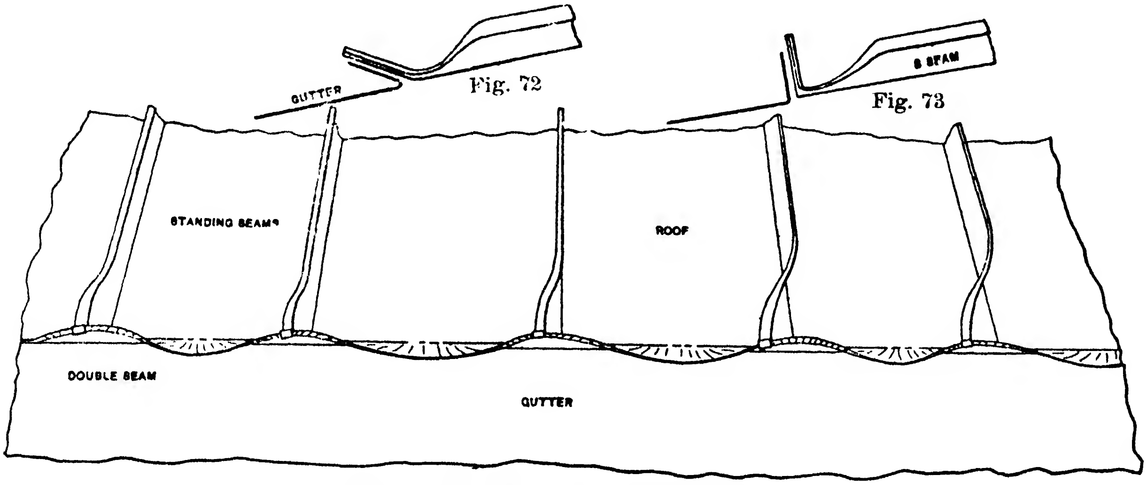


Fig. 72

Fig. 73

Fig. 71. Standing Seam at the Gutter Line

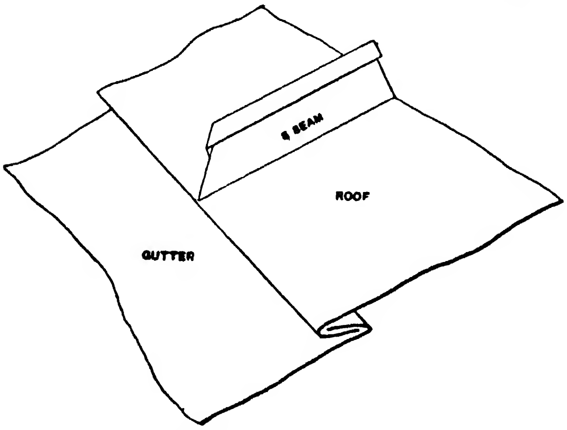


Fig. 74. Gutter Connection

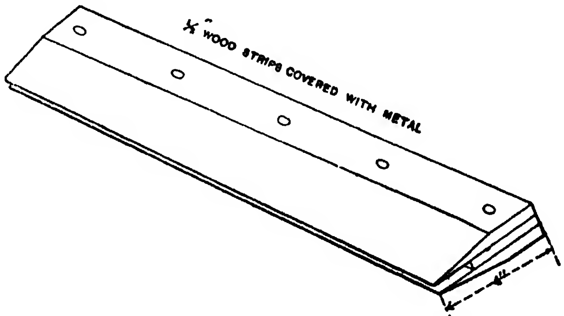


Fig. 75. Edge Turner

being usually 14 to 20 inches long and thus turning up that length of tin at each bite, the stretching of the edges is almost entirely avoided, and the finished result is a course with straight and rigid standing edges, as indicated in Fig. 67, so that when they are brought together for double seaming the first operation is much easier than if the edge had been stretched and buckled.

In tonging it is necessary to go over the edge twice—the first time turning it half way up, or to an angle of 45 degrees, and the second time finishing it as indi-

cated in Fig. 68. In passing, attention is called to a defect in most roof tongs, viz., lack of bearing surface around the pivot bolt *b*. The result of lack of this bearing surface is seen in Fig. 69. When the handles are operated to open the tongs, one side or the other of the blades, from some cause, such as being held by friction against the gauge, etc., may remain nearly closed, while the other side is opened much wider than necessary, and in sliding the tongs along the edge of the tin the

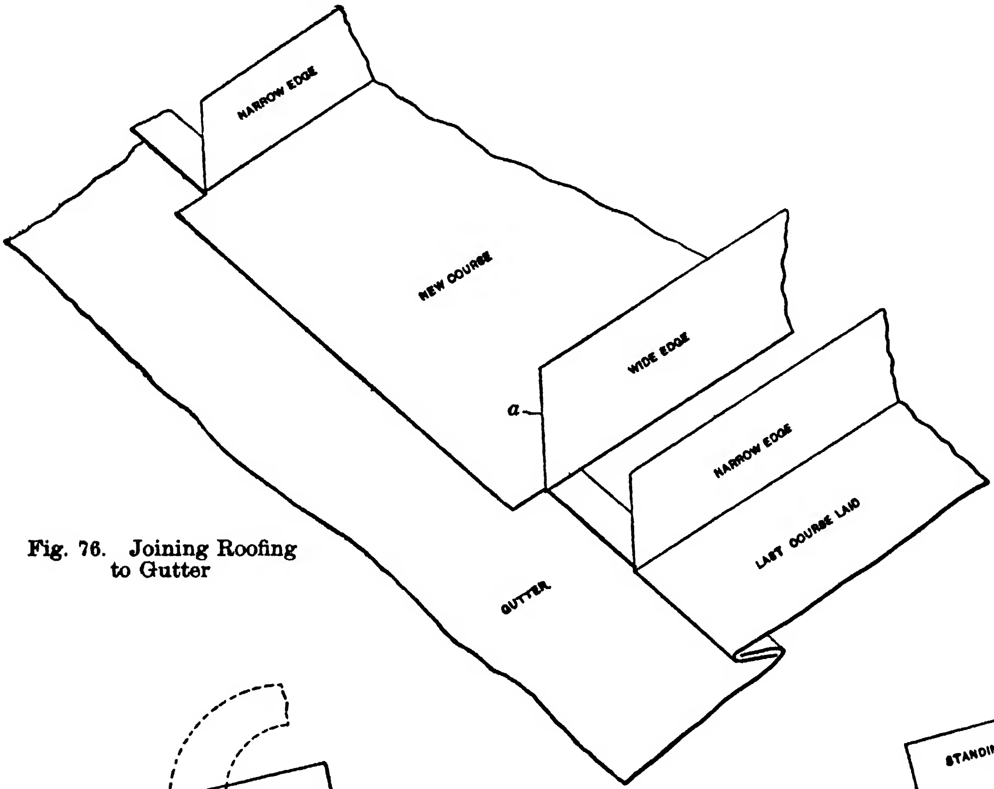


Fig. 76. Joining Roofing to Gutter

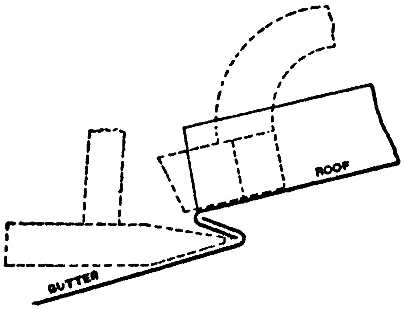


Fig. 78. Peening Edge into Gutter Flange

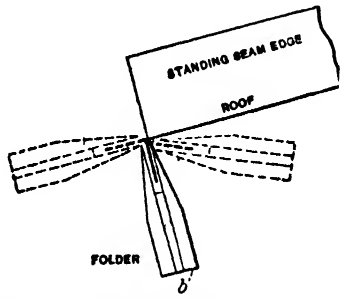


Fig. 77. Turning Edge on Roofing

side thus remaining nearly closed is liable and in fact does usually strike against the seams, as indicated at *a*, causing annoyance and delay. The tongs shown in Fig. 69 are as they are usually made, *i. e.*, with scant bearing surface around the rivet bolt *b*. Fig. 70 indicates how this working part should be made. When thus made and the bolt is kept as tight as possible without making the tongs work hard, the blades will be held parallel in opening and closing the tongs.

Where the gutter conditions are such that snow and ice are not likely to lie or

water to back up on the roof, a good and cheap method of joining the courses to the gutter is shown in Fig. 71. The first operation in producing this joint is shown in Fig. 72, a 1¼-inch edge being turned on the gutter, the roof courses being cut off so as to project a scant ¼ inch over this edge, and the bottom ends of the double seams being flattened over, as shown. The second operation is indicated in Fig. 73, the two edges having been turned up perpendicular to the roof with the 1½-inch gauge roofing tongs. The edges thus turned up are then double seamed, after which this gutter double seam is malletted over flat in the center of the courses, allowing that portion at the bottom ends of the double seams to stand nearly perpendicular as indicated in Fig 71. This gutter seam is not hammered down at the last named points, for the reason that the tin folded into the double seam would be likely to break when straightened out again, and furthermore when left standing at the point shown the seam is better drained and less likely to leak.

Where there is some possibility of water being backed up to the level of the gutter seam, the method of joining indicated in Fig. 74 is best. In making this connection a hand folder, as indicated in Fig. 75, is very useful. A ½-inch edge is turned on the edge of the gutter, and the course is cut just long enough to project ½ inch over this edge, as indicated in Fig. 76, the standing seams being notched just flush with the edge of the gutter as indicated at *a*. The bottom end of the course is then raised about 6 inches above the roof, and the hand folder, Fig. 75, slipped on to the edge and the edge turned as indicated in Fig. 77. If the course has not been cleated or secured in position, the edge can be turned under to the point *a*, and then the course let down low enough to allow hooking on to the edge of the gutter and then drawn up taut and secured, but if the course has been clamp tongued into position and is being cleated, the edge should only be turned down square as indicated at *b*. The course is then pressed down on the gutter edge, and has its edge held down by a weight (a hand seamer is very convenient for this purpose) and the edge tucked under with a hammer as indicated in Fig. 78, after which it can be malletted down.

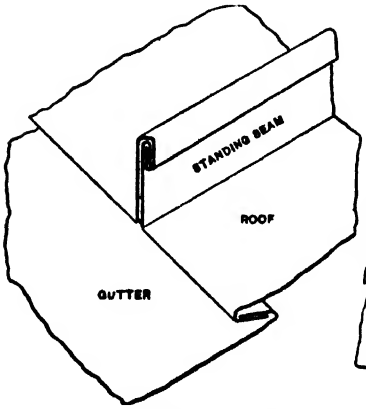


Fig. 79. Finish of Butts

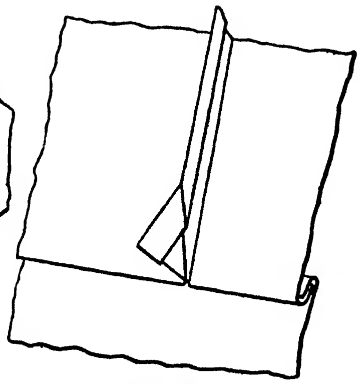


Fig. 80

Attention is called to the advisability of refraining from tightly malletting

down such lock edges until they are about to be soldered, as the sharp bending of the material, resulting from tightly malletting down, opens up the pores, so to speak, of the tin coating and one night's exposure to the atmosphere causes rusting and the surfaces of the tin in the lock being brought close together, capillary attraction holds considerable moisture in the seam, which fact, together with the rust, makes soldering very much more difficult than if the seams had been left open with rounded unbroken edges and separated surfaces, as in the latter case neither corrosion nor capillary attraction takes place to amount to anything, even if the seams are left in this condition for several days and are subjected to rainstorms.

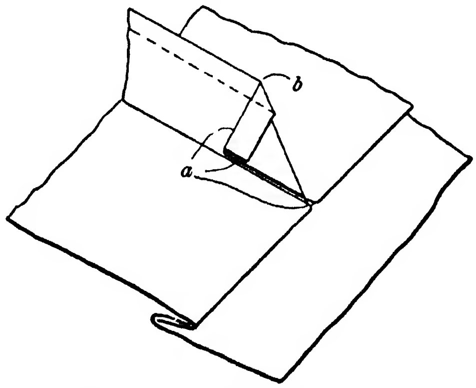


Fig. 81. Butt Finish Complete

A good method of finishing the butts of double seams is indicated in Fig. 74. The operations involved are as follows: First the double seam is left as shown in Fig. 79; the end of the seam is then turned by means of a hammer and heavy

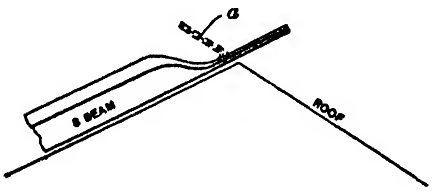


Fig. 82

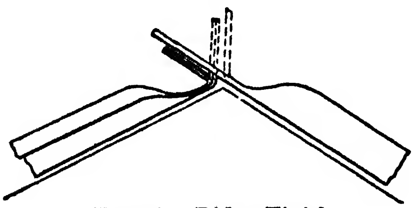


Fig. 83. Ridge Finish

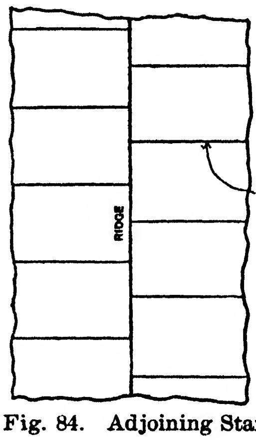


Fig. 84. Adjoining Standing Seam

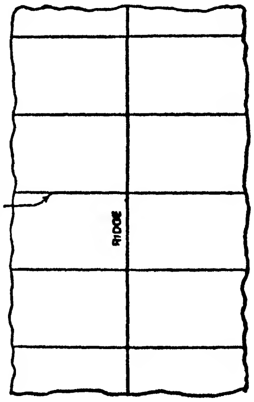


Fig. 85

chisel, as indicated in Fig. 80, and finished as indicated in Fig. 81. The butt is well soldered at the points *a*, Fig. 81, making a perfectly tight roof surface up to the top of the double seam at the point *b*. All that has been said about joining the roof to the gutter also applies to joining the roof to valleys.

A good method of finishing the ridge is by double seaming. When covering the first side of the slope the tin should be left projecting 1¼ inches above the ridge and the double seams finished and flattened down as indicated in Fig. 82, after which this 1¼ inch edge is turned back parallel to the second slope of the

roof, as indicated by dotted lines *a*, Fig. 82. When the other slope of the roof is covered the tin should be left projecting a scant ¼ inch above the last named edge and the double seams finished and flattened down at the ends as indicated in Fig. 83. Both edges are then turned up vertically, as indicated by dotted lines, Fig. 83, and double seamed together.

In laying the two slopes of roof care should be taken to have the double seams

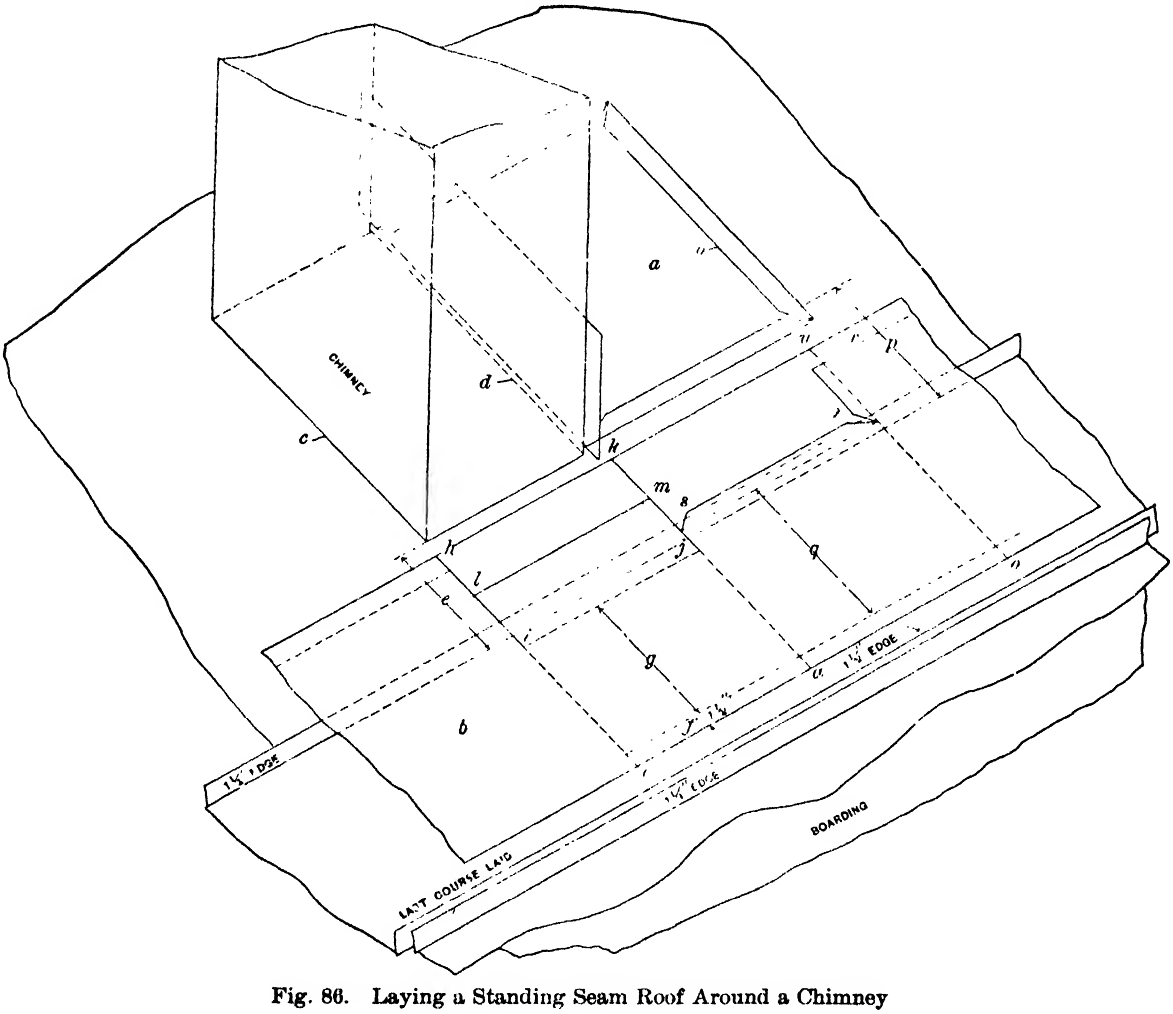


Fig. 86. Laying a Standing Seam Roof Around a Chimney

dodge each other, as indicated in Fig. 84, even though it should be necessary to start the second half of the roof with a half width course cut especially for this purpose. If the double seams hit each other as indicated in Fig. 85 it will be found a practical impossibility to double seam the ridge. What has been said about ridges also applies to hips.

We will assume that a roof has been started and a chimney is encountered.

Assuming the chimney to be of average size, the first thing to do is to lay a cricket behind the chimney, as indicated at *a*, Fig. 86, extending well up on the chimney sufficiently high to insure against water running over it when snow is banked behind, and extending up the roof far enough to bring the edge on a level with the top edge of the tin against the chimney. Cricket *a* should have a ½ inch lock turned on its upper edge and sides.

Supposing the tin to have been laid up to within a half course or so of the chimney, the next course *b* is laid alongside of the chimney before being edged up.

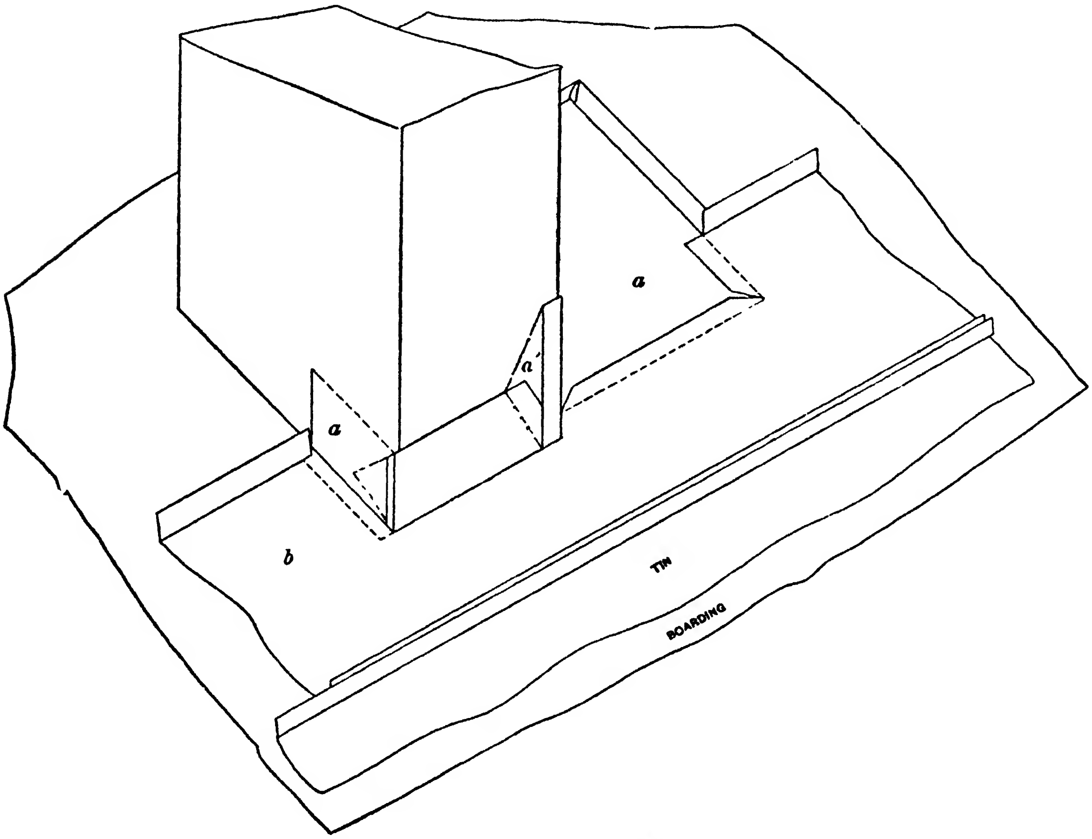
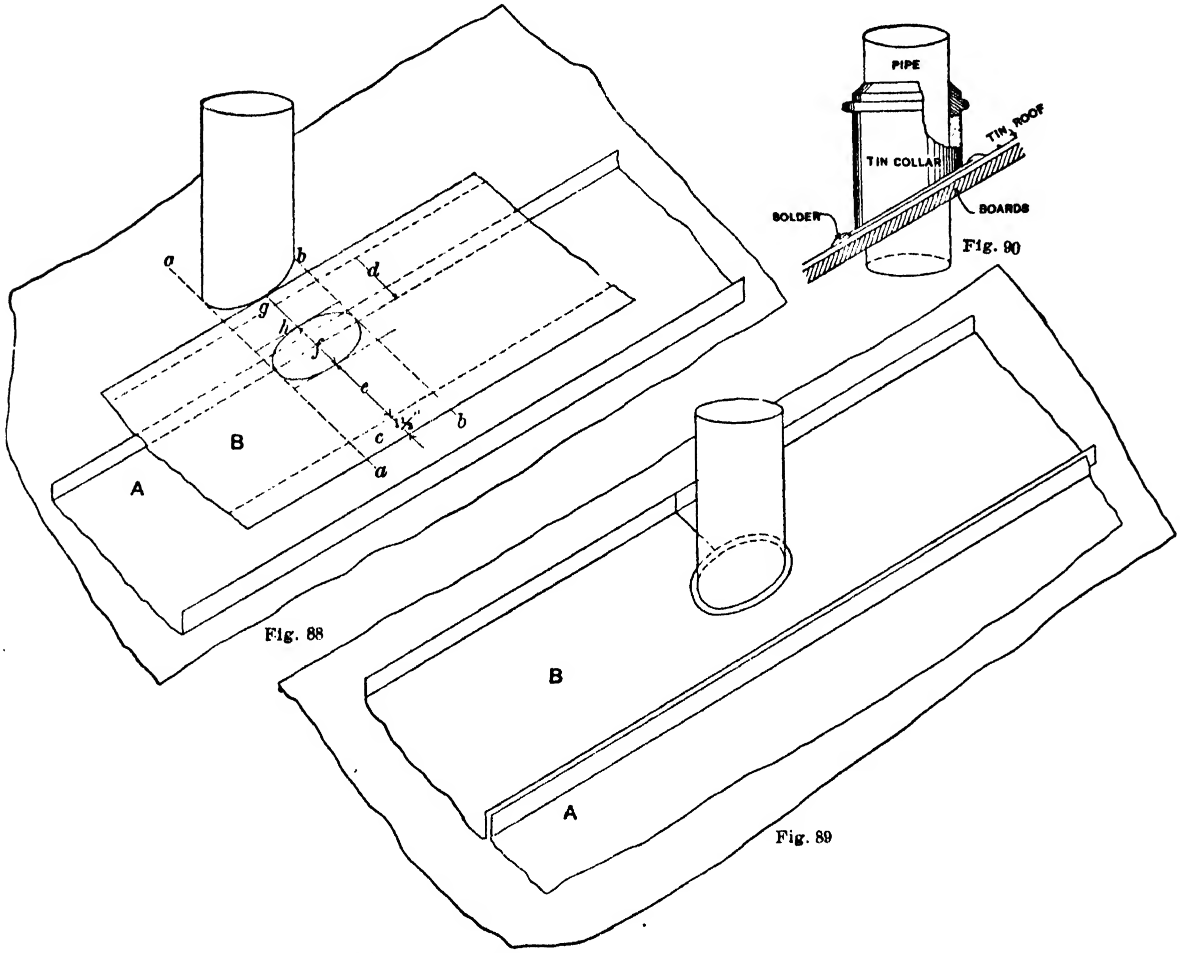


Fig. 87. Laying a Standing Seam Roof Around a Chimney

A straight edge is then laid along the bottom edge of the chimney at *c*, extending across course *b* and a line struck. The straight edge is then shifted to the top edge of chimney, as indicated at *d*, and another line struck. The last course laid usually has its 1¼-inch edge next the chimney, so that the edge to be turned on the new course to be double seamed with said edge should be 1½ inches wide. Therefore measure 1½ inches in from the edge of *b*, as indicated at *f*; and then take the distance *e* from side of chimney to the side of last course laid and set it off as indicated at *g*. Thus the lines *h i*, *j k* indicate the opening which must be made in the

new course to slip by the chimney. As the tin should turn up at least 6 inches against the side of chimney, measure off 6 inches from line *i j*, as indicated by the line *l m*.

The straight edge should now be laid against the lock edge of cricket piece, *a*, in the position indicated by dotted line *o*, and a line struck across the course. The distance from the edge of the side lock of the cricket piece to the side of last course



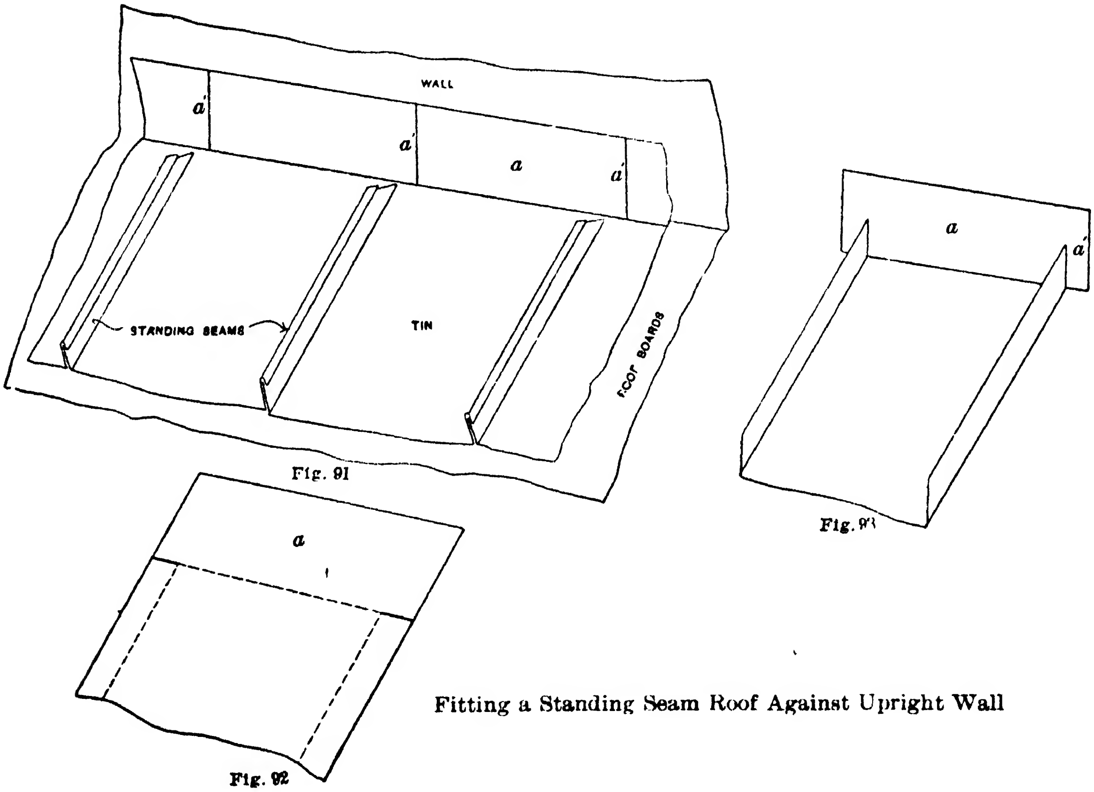
Laying a Standing Seam Roof Around a Pipe

laid, as indicated by *p*, should then be laid off at *q*, and ½ inch allowed for locking onto the top and side edges of the cricket piece.

Now cut lines *h i*, *k j*, *l m*, *s t*, *u*. Edge up the course and bend the tin up square on line *i j*, which fits against the side of chimney. Course *b* is then ready to place in position, as indicated in Fig. 87, after which the edges which lock upon top and sides of cricket at *a* are turned with the fingers and the peen of the hammer in the usual way. The course on the other side of the chimney is laid out and

handled in a similar manner. The back of chimney then has the piece *a* and *a'*, indicated by the dotted lines in Fig. 87, soldered in place, after which the chimney is ready for counterflashing in the usual way.

When a pipe is encountered, as indicated in Fig. 88, an opening is cut in the tin through which it is to pass in the following manner: Strike lines across the course from a straight edge placed against the top and bottom surface of the pipe next the roof, as indicated at *a* and *b*. Lay off 1½-inch edge *c*, then lay off distance *d* at *e;* make *f* equal to diameter of pipe, and trace an ellipse within the rec-

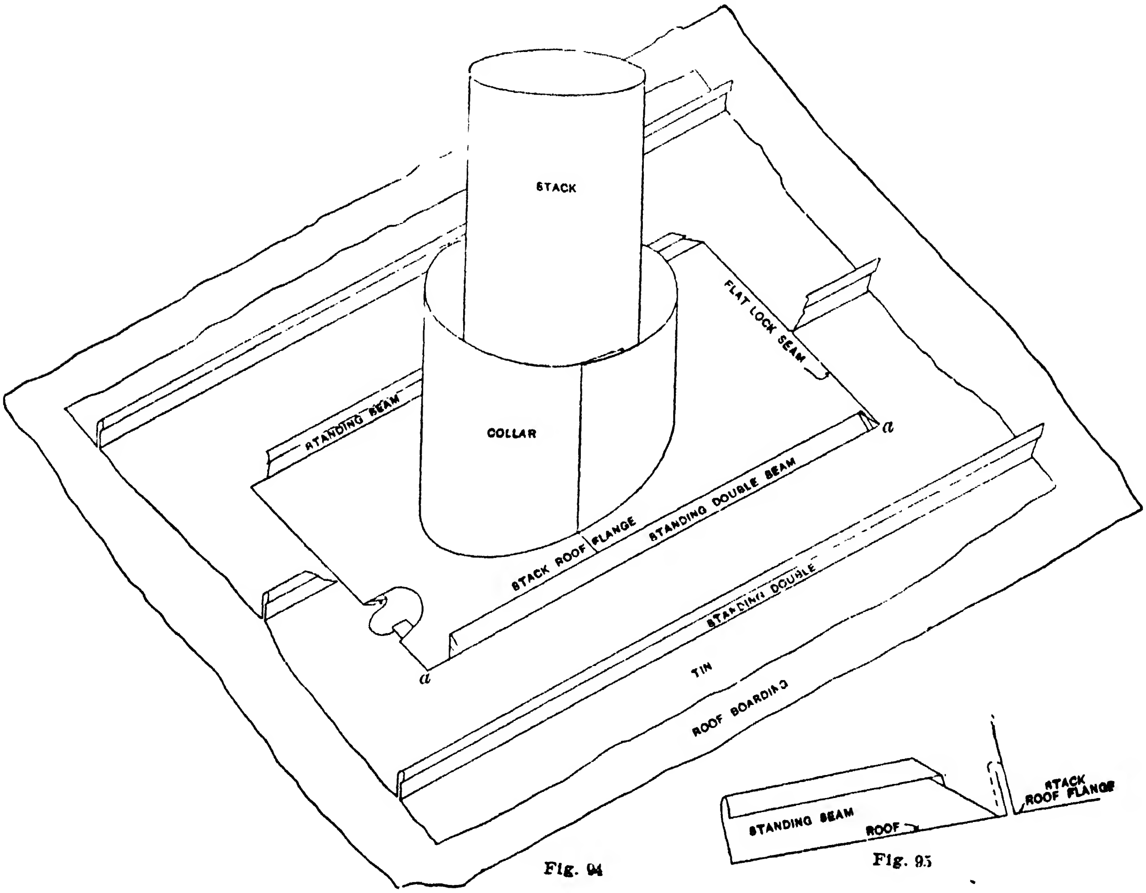


Fitting a Standing Seam Roof Against Upright Wall

tangle thus laid out, as indicated. If the pipe extends up too high to allow of raising the course up and slipping it down over the pipe, cut into the ellipse from the side of the course, as indicated by *g h*, and cut out the ellipse. Now turn up the 1½-inch edge on the new course and open up the cut *g h* to allow of slipping the tin by the pipe. Then the 1¼-inch edge can be turned and the course cleated and double seamed into position, as indicated in Fig. 89, and cut *g d* soldered up. If the pipe never gets hot a very good finish around it can be made by simply providing and soldering a collar around the pipe, calked with oakum and elastic cement, as indicated in Fig. 90. A stout copper wire should be twisted around

the collar near the top edge and be drawn tight before the lap is soldered, which will keep the collar perfectly tight against the piece of calking.

Fig. 91 shows a good way to finish the top of the courses against a monitor or other upright wall. Assuming that the tin is to be turned up 6 inches the top of the courses should be notched, as indicated by the solid lines of Fig. 92, 6 inches from top end. After the course is tongued up and the 6-inch flashing part turned up it looks like Fig. 93. The butts of the double seams are finished as indicated



Finishing a Standing Seam Roof Around Smokestack

in Fig. 81, page 46. The laps a', Fig. 91, as well as the butt ends of the double seams, are of course well soldered. If it be a clapboarded monitor or side wall against which the top of the courses finish the boarding of course simply laps down over the upturned tin, but if it be brick work the upturned flashing edge is counterflashed in the usual manner.

A good method of finishing around smoke stacks is shown in Fig. 94. It was shown how the roof flange of the smoke stack should be provided with lock edges

for joining on tin roofs. Where the stack is of such size as to make the distance *a a* considerable it is advantageous to double seam the roof flange to the tin roofing, along the sides, instead of locking and soldering. All flat soldered seams that run parallel with the rafters should be avoided, so far as possible, as the soldering is sure to break sooner or later and cause leaks, whereas the standing double seam is just as cheap to make, if not cheaper, and will never leak.

The roofing should be locked to the top edge of the roof flange and butts of double seams finished in the same manner as previously described and illustrated in Fig. 81. The connection between the lower edge of the roof flange and roof is finished in substantially the same manner, except that the process of making the connection differs. The seam should be made so as to shed the water downward. Solid lines of Fig. 95 indicate the operation, which consists of, first, turning a 1-inch edge perpendicular to the roof on the bottom of the roof flange and preparing the top portion of the course that connects to it, as indicated in Figs. 92 and 93, the only difference being that ½ inch is turned up instead of 6 inches. The double seam is then finished, after which the roof flange is single seamed over the top edge of the course, as indicated by the dotted line of Fig. 95, and then the seam is malleted down, as shown in the broken view of Fig. 94. This seam, as well as the lock seam at the top of the roof flange and all butts, are soldered.

If a roof has sufficient pitch there is little or no danger of standing seams leaking. If they should even after they have been gone over with a mallet they may be soldered where necessary by turning seams over enough to permit soldering after which they can be straightened up square again or seams can be painted with white lead by means of a small brush.

It might be stated that while the soldering of cross seams was advised, some roofers claim it is best not to solder these cross seams, saying it allows for a free movement of the metal when expanding and contracting.

For a large class of roofing—*i. e.*, when a particular brand or quality, which cannot be had except in loose sheets, boxed, is not required—the entire question of putting tin together in strips or rolls is best solved by purchasing it already put together in rolls, painted or unpainted. Tin in this form is to be had from a number of concerns, some of it being put up in rolls consisting of 20×28 sheets locked together, soldered and painted in the usual manner by hand. While other brands consist of long sheets, some as long as 10 feet, the completed rolls being produced by a machine something like 80 feet long. As a general proposition, for ordinary roofing the long sheet answers very well.

ROOF CLEATS FOR FLAT SEAM

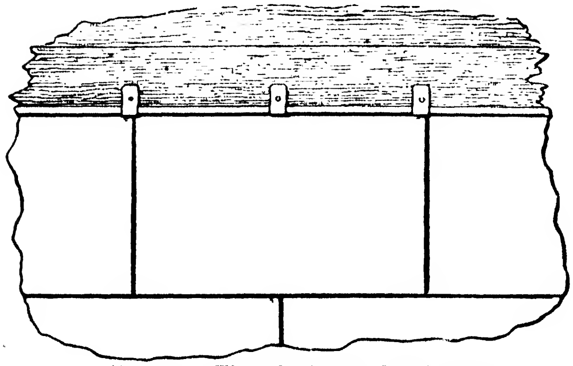


Fig. 96. The Placing of Roof Cleats

Another method of cleating to that recommended in Fig. 25, page 675, is to place a cleat on the top of the two sheets where their edges come together, as shown in Fig. 96. This covers the two laps and holds tightly down in its place the sheet which covers this lap. When the cleats are placed in this way the sheet is not apt to buckle when soldering, as it will invariably rise up slightly owing to the expansion caused by the hot copper.

USE OF PAPER UNDER TIN ROOFS

Paper used under a tin roof deadens the noise and protects the tin from the effect of unsatisfactory sheathing boards. Some insist that a waterproof paper should be used and others prefer a soft felt. There are others who think that the tin should be painted on the under side and then there is no occasion for the use of any kind of paper. They hold the opinion that should there happen to be a leak in the tin roof waterproof paper will keep a pool of water under the tin to help in its destruction. If a sufficient quantity gets there it will run for some distance on the paper before it makes itself manifest underneath, which adds to the difficulty in locating the leak when repairs are to be made. At times a felt has been used containing destructive chemicals in its makeup, which have been detrimental to the durability of the tin plate. When the tin is heavily coated, whether protected with a coat of paint afterwards or not, there are those who believe that there is no need for paper under it, if it is laid on well seasoned dry sheathing boards, laid smoothly, and if an air space is provided underneath the roof to prevent condensation on the under side.

If paper is used under the tin it must be paper that has in its composition nothing injurious to the tin, as tar, sulphur, etc. Many cases have been cited of entire roofs being destroyed owing to this.

COVERING A CONICAL TOWER WITH SHEET METAL

One of the most difficult jobs in flat or standing seam roofing is that of covering a conical tower. As the roof in question is round in plan and tapering in elevation, it is necessary to know the method for cutting the various patterns. In Fig. 97, let A B C be the elevation of a tower to be covered with flat seam roofing, using 10×14 inch tin at the base; the tinning to be laid on two-ply felting, and each sheet nailed with four ⅞-inch wire nails, the sheets being edged not less than ⅜ inch to insure a good lock. Assuming that the tower at B C is 10 feet 6 inches in diameter, we will, at any convenient place at the building, strike a quarter plan, as for example that indicated by J E F, which will be used when getting out the pattern for the bottom of the gutter shown by dotted lines at B and C. The straight part of the gutter requires no pattern, and the slant part is obtained the same as for flaring work. As the diameter of the tower is 10 feet 6 inches and equals 126 inches, the circumference is obtained by multiplying this amount by 3 1-7, which equals 396 inches. As 10×14 inch tin plate is to be used at the base of the tower, the nearest width which can be employed and which will divide the base in equal spaces is 13 1-5 inches without laps, thus dividing the circumference into 30 equal spaces. This width of 13 1-5 inches and the length of the rafter A B or A C in elevation will be the basis from which to construct a triangle, in which all the patterns for the various courses will be laid off.

To obtain the patterns for the various courses proceed as follows: It should be understood that the diagram which will now be constructed will be enlarged so as to better show the methods involved. At any convenient place at the building stretch a piece of tar felting of the required length, tacking it at the four corners with nails to keep it from slipping. Upon the center of the felting strike a chalk line, as A B of Fig. 98, making it equal to the length of the rafter A B or A C of Fig. 97. At right angles to A B, Fig. 98, at either side, draw the lines B D and B C, each equal to 6 3-5 inches, being one-half 13 1-5 above referred to. From the points C and D draw lines to the apex A. As the width of the sheet used is 10 inches, and as ⅜-inch edges are put on each side, thus leaving 9¼ inches, measure on the vertical line A B 9¼ inches in succession, until the apex A is reached. Through the points thus obtained on A B draw lines parallel to C D intersecting the lines A C and A D, as shown. Then will the various patterns 1, 2, 3 and 4 be the net patterns for courses having similar numbers.

Take the shears and cut out the patterns on the felting and number them as

required. For example, take the paper pattern number 1, place it on a sheet of tin, as shown in Fig. 99, and allow ⅜ inch edges all around, and notch the corners, as shown by A, B, C and D. Mark on the tin pattern No. 1 29 more, as 30 are required to go around the tower. Treat all the paper patterns from 1 to the apex in similar manner.

Of course where the patterns become smaller in size, as at the top, the waste from other patterns can be used.

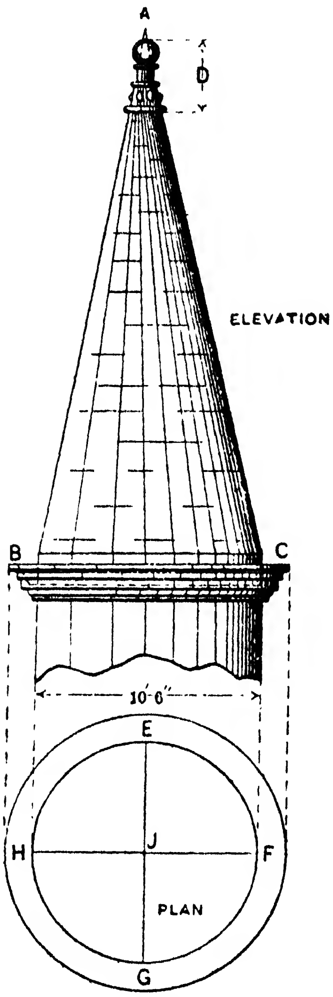


Fig. 97. Plan and Elevation

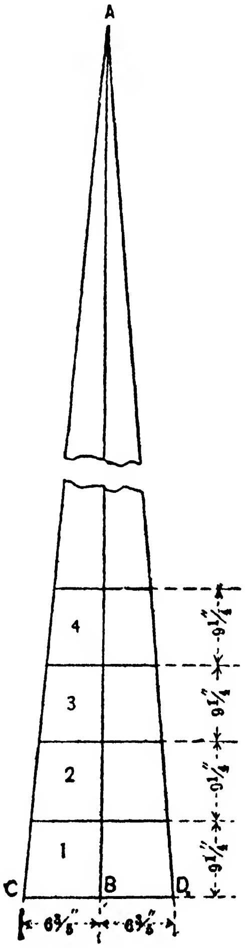


Fig. 98. Obtaining Patterns for the Various Courses

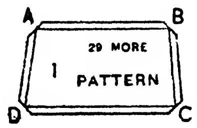


Fig. 99. Showing Edges to Patterns

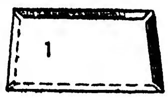


Fig. 100. An Edged Sheet

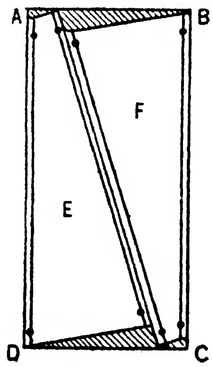


Fig. 102. Showing How to Cut the Metal

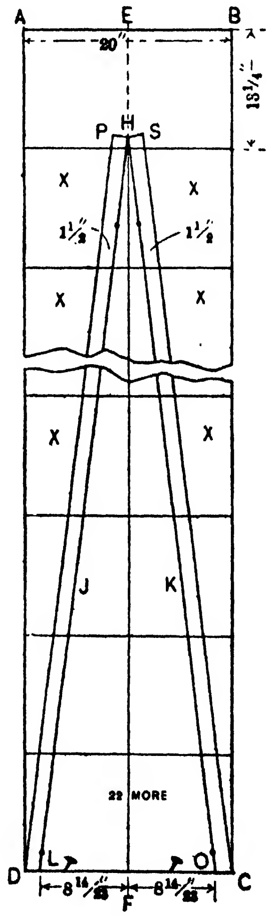


Fig. 101. Obtaining Patterns for Standing Seam Strip

In Fig. 100 is shown how the sheet should be edged, always being careful to have the narrow side toward the top, with the edges at the narrow and right hand side toward the outside, while the lower and left hand edges are edged toward the inside, all as shown in the diagram. Lay the sheets in the usual manner, breaking

joints as in ordinary practice. As the seams are not soldered, be careful to avoid making "busters"—in other words, failing to interlock the joints.

After the entire roof is laid, and before "pounding down," or closing the seams with a mallet, take a tool brush and paint the locks with thick white lead, then close with the mallet. This will make a tight job.

The roof being covered, put the finial, D of Fig. 97, in position, when the job is ready for the painter. As the method used for obtaining the patterns for the various sheets in Fig. 98 is based upon the principle used in obtaining the envelope of a right cone, some readers may say that in accurate patterns the line from C to D should be curved, and not straight, as shown. To those it is said that the curve would be so little on a small pattern where the radius is long that a straight line answers the purpose just as well in all practical work, for it would amount to considerable labor to turn edges on the curved cut of the sheet, and there is certainly no necessity for it. Supposing now that the tower shown in Fig. 97 were to be covered with standing seam roofing, the method of obtaining the pattern would be a little different. As the reader knows, standing seam roofing, when required in single sheets, is prepared by locking together sheets of the required number, the cross seams being soldered, the side edges then being bent up on each side 1¼ and 1½ inches respectively by means of the roofing tongs. Care should be taken when bending the standing seams that the cross seams do not crack, and to examine same before laying on the roof, as this is very often the cause of leaks which are very hard to find afterward. As the circumference of the tower at its base is 396 inches, and assuming that 14×20 inch plate is to be used at the base of the tower, the nearest width which can be employed and which will divide the base into equal spaces is 17 5-23 inches, without edges, thus dividing the circumference into 23 equal parts. Then will this width of 17 5-23 inches and the length of the rafter A B or A C in elevation be the basis from which to construct the pattern for the standing seam strip, for which proceed as follows: Let A B C D in Fig. 101 represent a 20-inch strip "knocked out," or locked together and soldered, using ⅜-inch edges; through the center of this strip draw the line E F. Now measure the length of the rafter A B or A C in Fig. 97, and place it on the line E F in Fig. 101, as shown, from H to F. At right angles to H F on either side draw the lines F O and F L, making each side equal to 8 14-23 inch, being one-half of the 17 5-23 above referred to. From points L and O draw lines to the apex H. At right angles to H L and H O draw the lines H P, equal to 1¼ inches, and H S, equal to 1½ inches, respectively. From points P and S and parallel to H L and H O draw the lines P D and S C respectively. Then will P S C D be the pattern

for the standing seam strip, of which 22 more will be required. When getting out the balance of the 22 strips it can be accomplished in the quickest way as follows:

Take the pattern just cut, lay it upon the roof or bench, and scribe a chalk line around the entire pattern; remove the pattern. Now start with a 14×20 inch sheet and tack it with nails at its lower end to keep it from slipping, as at L and O; then, having the chalk line just scribed as a guide, lay the following sheets, being careful to use the waste as the apex is reached. After having "knocked out" 22 of these strips and soldered the same, the pattern is laid over each one and accurately marked, cut and bent up. It is then laid on the tower, fastened with cleats and doubled seamed with the hand seamer and mallet in the usual manner. If the tower was done in copper or galvanized sheet iron, where 8-foot material could be used, as many sheets would be locked together as required; then metal could be saved and waste avoided by cutting the sheets as shown in Fig. 102, in which A B C D shows the sheet of metal and E and F the pattern sheets, the only waste being shown by the shaded portion.

Where the finial sets over the tower, as at D in Fig. 97, the standing seams are turned over flat as much as is required to receive the finial, or small notches would be cut into the base of the finial as to allow it to slip over the standing seams. Before closing the standing seams take a brush and fill seams with white lead, then close up tight, which will make a good joint.

ROOFING OF A LARGE DOME

The tin work on the dome, Fig. 103, was laid as follows: After finding the exact center or axis of the dome on top a large wood template was made shaping the under edge to conform with the curve of the dome. A line was then struck at the base of the dome, drawing a circle all around to start the tin straight; then dividing this line up into exact number of equal spaces, the first row of sheets was cut in the shape of a triangle and the locks turned on same, always with the idea of having the water to run over the seams, and not against them. The sheets of the next row were cut perfectly square, with one corner up, the opposite corner down, and locked the joints. Each following row was cut square and of the correct size to circle

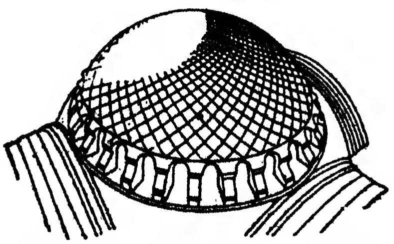


Fig. 103. Roofing a Large Dome

the dome. This allows the bending of the sheets to fit the shape of the dome, and make a perfect, smooth roof, conforming with the curve of the dome without a wrinkle. The seams were all hammered flat and smooth, and at a distance it looks like a concrete roof.

As the illustration shows, the sheets are laid diamond-shape, reducing the size of the sheets as they near the top, and laying them so that every edge on the sheet overlaps the lower edge, to shed water perfectly. The flat portion on the top of the roof was laid like any flat roof would be laid and soldered.

QUANTITY OF TIN FOR ROOFS—Continued

GIVING THE NUMBER OF BOXES AND SHEETS REQUIRED TO COVER ROOFS OF VARIOUS SIZES, RANGING FROM 10 TO 10,000 SQUARE FEET

SURFACE OF ROOF TO BE COVERED	FLAT SEAM								STANDING SEAM															
	Edged ¼ in.				Edged ⅜ in.				Single Lock								Double Lock							
									¾-in. seam.				1-in. seam.				¾-in. seam.				1-in. seam.			
	Covering space 13 x 19 in. Exposing surface 247 sq. in.		Covering space 19 x 27 in. Exposing surface 513 sq. in.		Covering space 12⅞ x 18⅞ in. Exposing surface 243 1/64 sq. in.		Covering space 18⅞ x 26⅞ in. Exposing surface 507 17/64 sq. in		Covering 228 17/32 sq. in. Edged 1 and 1¼ in.		Covering 477 1/32 sq. in. Edged 1 and 1¼ in.		Covering 222 3/32 sq. in. Edged 1¼ and 1½ in.		Covering 463 19/32 sq. in. Edged 1¼ and 1½ in.		Covering 228 63/64 sq. in. Edged 1 and 1¼ in.		Covering 471 31/64 sq. in. Edged 1 and 1¼ in.		Covering 216 45/64 sq. in. Edged 1¼ and 1½ in.		Covering 458 13/64 sq. in. Edged 1¼ and 1½ in.	
	14 x 20		20 x 28		14 x 20		20 x 28		14 x 20		20 x 28		14 x 20		20 x 28		14 x 20		20 x 28		14 x 20		20 x 28	
Sq. ft.	B.	S.	B.	S.	B.	S.	B.	S.	B.	S.	B.	S.	B.	S.	B.	S.	B.	S.	B.	S.	B.	S.	B.	S.
10	0	6	0	3	0	6	0	3	0	7	0	4	0	7	0	4	0	7	0	4	0	7	0	4
11	0	7	0	4	0	7	0	4	0	7	0	4	0	8	0	4	0	8	0	4	0	8	0	4
12	0	7	0	4	0	8	0	4	0	8	0	4	0	8	0	4	0	8	0	4	0	8	0	4
13	0	8	0	4	0	8	0	4	0	9	0	4	0	9	0	5	0	9	0	4	0	9	0	5
14	0	9	0	4	0	9	0	4	0	9	0	5	0	10	0	5	0	10	0	5	0	10	0	5
15	0	9	0	5	0	9	0	5	0	10	0	5	0	10	0	5	0	10	0	5	0	10	0	5
16	0	10	0	5	0	10	0	5	0	11	0	5	0	11	0	5	0	11	0	5	0	11	0	6
17	0	10	0	5	0	11	0	5	0	11	0	6	0	12	0	6	0	11	0	6	0	12	0	6
18	0	11	0	6	0	11	0	6	0	12	0	6	0	12	0	6	0	12	0	6	0	12	0	6
19	0	12	0	6	0	12	0	6	0	12	0	6	0	13	0	6	0	13	0	6	0	13	0	6
20	0	12	0	6	0	12	0	6	0	13	0	7	0	13	0	7	0	13	0	7	0	14	0	7
21	0	13	0	6	0	13	0	6	0	14	0	7	0	14	0	7	0	14	0	7	0	14	0	7
22	0	13	0	7	0	14	0	7	0	14	0	7	0	15	0	7	0	15	0	7	0	15	0	7
23	0	14	0	7	0	14	0	7	0	15	0	7	0	15	0	8	0	15	0	8	0	16	0	8
24	0	14	0	7	0	15	0	7	0	16	0	8	0	16	0	8	0	16	0	8	0	16	0	8
25	0	15	0	8	0	15	0	8	0	16	0	8	0	17	0	8	0	17	0	8	0	17	0	8
26	0	16	0	8	0	16	0	8	0	17	0	8	0	17	0	9	0	17	0	8	0	18	0	9
27	0	16	0	8	0	16	0	8	0	18	0	9	0	18	0	9	0	18	0	9	0	18	0	9
28	0	17	0	8	0	17	0	8	0	18	0	9	0	19	0	9	0	19	0	9	0	19	0	9
29	0	17	0	9	0	18	0	9	0	19	0	9	0	19	0	10	0	19	0	9	0	20	0	10
30	0	18	0	9	0	18	0	9	0	19	0	10	0	20	0	10	0	20	0	10	0	20	0	10
31	0	19	0	9	0	19	0	9	0	20	0	10	0	21	0	10	0	21	0	10	0	21	0	10
32	0	19	0	9	0	19	0	10	0	21	0	10	0	21	0	10	0	21	0	10	0	22	0	11
33	0	20	0	10	0	20	0	10	0	21	0	10	0	22	0	11	0	22	0	11	0	22	0	11
34	0	20	0	10	0	21	0	10	0	22	0	11	0	23	0	11	0	22	0	11	0	23	0	11
35	0	21	0	10	0	21	0	10	0	23	0	11	0	23	0	11	0	23	0	11	0	24	0	11
36	0	21	0	11	0	22	0	11	0	23	0	11	0	24	0	12	0	24	0	11	0	24	0	12
37	0	22	0	11	0	22	0	11	0	24	0	12	0	24	0	12	0	24	0	12	0	25	0	12
38	0	23	0	11	9	23	0	11	0	24	0	12	0	25	0	12	0	25	0	12	0	26	0	12
39	0	23	0	11	0	24	0	12	0	25	0	12	0	26	0	13	0	26	0	12	0	26	0	13
40	0	24	0	12	0	24	0	12	0	26	0	13	0	26	0	13	0	26	0	13	0	27	0	13
41	0	24	0	12	0	25	0	12	0	26	0	13	0	27	0	13	0	27	0	13	0	28	0	13
42	0	25	0	12	0	25	0	12	0	27	0	13	0	28	0	14	0	28	0	13	0	28	0	14
43	0	26	0	13	0	26	0	13	0	28	0	13	0	28	0	14	0	28	0	14	0	29	0	14
44	0	26	0	13	0	27	0	13	0	28	0	14	0	29	0	14	0	29	0	14	0	30	0	14

QUANTITY OF TIN FOR ROOFS—Continued

GIVING THE NUMBER OF BOXES AND SHEETS REQUIRED TO COVER ROOFS OF VARIOUS SIZES, RANGING FROM 10 TO 10,000 SQUARE FEET

SURFACE OF ROOF TO BE COVERED	FLAT SEAM								STANDING SEAM															
	Edged ¼ in.				Edged ⅜ in.				Single Lock								Double Lock							
									¾-in. seam.				1-in. seam.				¾-in. seam.				1-in. seam.			
	Covering space 18 x 19 in. Exposing surface 247 sq. in.		Covering space 19 x 27 in. Exposing surface 513 sq. in.		Covering space 12⅞ x 18⅞ in. Exposing surface 243 1/64 sq. in.		Covering space 18⅞ x 26⅞ in. Exposing surface 507 17/64 sq. in.		Covering 228 17/32 sq. in. Edged 1 and 1¼ in.		Covering 477 1/32 sq. in. Edged 1 and 1¼ in.		Covering 222 23/32 sq. in. Edged 1¼ and 1½ in.		Covering 463 19/32 sq. in. Edged 1¼ and 1½ in.		Covering 228 63/64 sq. in. Edged 1 and 1¼ in.		Covering 471 31/64 sq. in. Edged 1 and 1¼ in.		Covering 216 45/64 sq. in. Edged 1¼ and 1½ in.		Covering 458 13/64 sq. in. Edged 1¼ and 1½ in.	
	14 x 20		20 x 28		14 x 20		20 x 28		14 x 20		20 x 28		14 x 20		20 x 28		14 x 20		20 x 28		14 x 20		20 x 28	
Sq. ft.	B.	S.	B.	S.	B.	S.	B.	S.	B.	S.	B.	S.	B.	S.	B.	S.	B.	S.	B.	S.	B.	S.	B.	S.
45	0	27	0	13	0	27	0	13	0	29	0	14	0	30	0	14	0	30	0	14	0	30	0	15
46	0	27	0	13	0	28	0	14	0	29	0	14	0	30	0	15	0	30	0	15	0	31	0	15
47	0	28	0	14	0	28	0	14	0	30	0	15	0	31	0	15	0	31	0	15	0	32	0	15
48	0	28	0	14	0	29	0	14	0	31	0	15	0	32	0	15	0	31	0	15	0	32	0	16
49	0	29	0	14	0	30	0	14	0	31	0	15	0	32	0	16	0	32	0	15	0	33	0	16
50	0	30	0	15	0	30	0	15	0	32	0	16	0	33	0	16	0	33	0	16	0	34	0	16
51	0	30	0	15	0	31	0	15	0	33	0	16	0	34	0	16	0	33	0	16	0	34	0	17
52	0	31	0	15	0	31	0	15	0	33	0	16	0	34	0	17	0	34	0	16	0	35	0	17
53	0	31	0	15	0	32	0	16	0	34	0	16	0	35	0	17	0	35	0	17	0	36	0	17
54	0	32	0	16	0	32	0	16	0	35	0	17	0	36	0	17	0	35	0	17	0	36	0	17
55	0	33	0	16	0	33	0	16	0	35	0	17	0	36	0	18	0	36	0	17	0	37	0	18
56	0	33	0	16	0	34	0	16	0	36	0	17	0	37	0	18	0	37	0	18	0	38	0	18
57	0	34	0	16	0	34	0	17	0	36	0	18	0	37	0	18	0	37	0	18	0	38	0	18
58	0	34	0	17	0	35	0	17	0	37	0	18	0	38	0	19	0	38	0	18	0	39	0	19
59	0	35	0	17	0	35	0	17	0	38	0	18	0	39	0	19	0	39	0	19	0	40	0	19
60	0	35	0	17	0	36	0	18	0	38	0	19	0	39	0	19	0	39	0	19	0	40	0	19
61	0	36	0	18	0	37	0	18	0	39	0	19	0	40	0	19	0	40	0	19	0	41	0	20
62	0	37	0	18	0	37	0	18	0	40	0	19	0	41	0	20	0	41	0	19	0	42	0	20
63	0	37	0	18	0	38	0	18	0	40	0	20	0	41	0	20	0	41	0	20	0	42	0	20
64	0	38	0	18	0	38	0	19	0	41	0	20	0	42	0	20	0	42	0	20	0	43	0	21
65	0	38	0	19	0	39	0	19	0	41	0	20	0	43	0	21	0	42	0	20	0	44	0	21
66	0	39	0	19	0	40	0	19	0	42	0	20	0	43	0	21	0	43	0	21	0	44	0	21
67	0	40	0	19	0	40	0	20	0	43	0	21	0	44	0	21	0	44	0	21	0	45	0	22
68	0	40	0	20	0	41	0	20	0	43	0	21	0	45	0	22	0	44	0	21	0	46	0	22
69	0	41	0	20	0	41	0	20	0	44	0	21	0	45	0	22	0	45	0	22	0	46	0	22
70	0	41	0	20	0	42	0	20	0	45	0	22	0	46	0	22	0	46	0	22	0	47	0	22
71	0	42	0	20	0	43	0	21	0	45	0	22	0	47	0	23	0	46	0	22	0	48	0	23
72	0	42	0	21	0	43	0	21	0	46	0	22	0	47	0	23	0	47	0	22	0	48	0	23
73	0	43	0	21	0	44	0	21	0	46	0	23	0	48	0	23	0	48	0	23	0	49	0	23
74	0	44	0	21	0	44	0	22	0	47	0	23	0	48	0	23	0	48	0	23	0	50	0	24
75	0	44	0	22	0	45	0	22	0	48	0	23	0	49	0	24	0	49	0	23	0	50	0	24
76	0	45	0	22	0	46	0	22	0	48	0	23	0	50	0	24	0	50	0	24	0	51	0	24
77	0	45	0	22	0	46	0	22	0	49	0	24	0	50	0	24	0	50	0	24	0	52	0	25
78	0	46	0	22	0	47	0	23	0	50	0	24	0	51	0	25	0	51	0	24	0	52	0	25
79	0	47	0	23	0	47	0	23	0	50	0	24	0	52	0	25	0	52	0	25	0	53	0	25
80	0	47	0	23	0	48	0	23	0	51	0	25	0	52	0	25	0	52	0	25	0	54	0	26
81	0	48	0	23	0	48	0	23	0	52	0	25	0	53	0	26	0	53	0	25	0	54	0	26
82	0	48	0	24	0	49	0	24	0	52	0	25	0	54	0	26	0	53	0	26	0	55	0	26
83	0	49	0	24	0	50	0	24	0	53	0	26	0	54	0	26	0	54	0	26	0	56	0	27
84	0	49	0	24	0	50	0	24	0	53	0	26	0	55	0	27	0	55	0	26	0	56	0	27
85	0	50	0	24	0	51	0	25	0	54	0	26	0	56	0	27	0	55	0	26	0	57	0	27
86	0	51	0	25	0	51	0	25	0	55	0	26	0	56	0	27	0	56	0	27	0	58	0	28
87	0	51	0	25	0	52	0	25	0	55	0	27	0	57	0	28	0	57	0	27	0	58	0	28
88	0	52	0	25	0	53	0	25	0	56	0	27	0	58	0	28	0	57	0	27	0	59	0	28
89	0	52	0	26	0	53	0	26	0	57	0	27	0	58	0	28	0	58	0	28	0	60	0	28
90	0	53	0	26	0	54	0	26	0	57	0	28	0	59	0	28	0	59	0	28	0	60	0	29
91	0	54	0	26	0	54	0	26	0	58	0	28	0	60	0	29	0	59	0	28	0	61	0	29
92	0	54	0	26	0	55	0	27	0	58	0	28	0	60	0	29	0	60	0	29	0	62	0	29
93	0	55	0	27	0	56	0	27	0	59	0	29	0	61	0	29	0	61	0	29	0	62	0	30
94	0	55	0	27	0	56	0	27	0	60	0	29	0	61	0	30	0	61	0	29	0	63	0	30
95	0	56	0	27	0	57	0	27	0	60	0	29	0	62	0	30	0	62	0	30	0	64	0	30
96	0	56	0	27	0	57	0	28	0	61	0	29	0	63	0	30	0	62	0	30	0	64	0	31
97	0	57	0	28	0	58	0	28	0	62	0	30	0	63	0	31	0	63	0	30	0	65	0	31
98	0	58	0	28	0	59	0	28	0	62	0	30	0	64	0	31	0	64	0	30	0	66	0	31
99	0	58	0	28	0	59	0	29	0	63	0	30	0	65	0	31	0	64	0	31	0	66	0	32

QUANTITY OF TIN FOR ROOFS—Continued

GIVING THE NUMBER OF BOXES AND SHEETS REQUIRED TO COVER ROOFS OF VARIOUS SIZES, RANGING FROM 10 TO 10,000 SQUARE FEET

SURFACE OF ROOF TO BE COVERED	FLAT SEAM								STANDING SEAM															
	Edged ¼ in.				Edged ⅜ in.				Single Lock								Double Lock							
									¾-in. seam				1-in. seam				¾-in. seam				1-in. seam			
	Covering space 13 x 19 in. Exposing surface 247 sq. in.		Covering space 19 x 27 in. Exposing surface 513 sq. in.		Covering space 12¾ x 18¾ in. Exposing surface 243 1/64 sq. in.		Covering space 18¾ x 26¾ in. Exposing surface 507 17/64 sq. in.		Covering 228 17/32 sq. in. Edged 1 and 1¼ in.		Covering 477 1/32 sq. in. Edged 1 and 1¼ in.		Covering 222 3/32 sq. in. Edged 1¼ and 1½ in.		Covering 463 19/32 sq. in. Edged 1¼ and 1½ in.		Covering 228 63/64 sq. in. Edged 1 and 1¼ in.		Covering 471 31/64 sq. in. Edged 1 and 1¼ in.		Covering 218 45/64 sq. in. Edged 1¼ and 1½ in.		Covering 458 13/64 sq. in. Edged 1¼ and 1½ in.	
	14 x 20		20 x 28		14 x 20		20 x 28		14 x 20		20 x 28		14 x 20		20 x 28		14 x 20		20 x 28		14 x 20		20 x 28	
Sq. ft.	B.	S.	B.	S.	B.	S.	B.	S.	B.	S.	B.	S.	B.	S.	B.	S.	B.	S.	B.	S.	B.	S.	B.	S.
100	0	59	0	29	0	60	0	29	0	64	0	31	0	65	0	32	0	65	0	31	0	67	0	32
200	1	5	0	57	1	7	0	57	1	15	0	61	1	18	0	63	1	18	0	62	1	21	0	63
300	1	63	0	85	1	66	0	86	1	78	0	91	1	83	0	94	1	82	0	92	1	88	0	95
400	2	10	1	1	2	14	1	2	2	29	1	9	2	36	1	13	2	35	1	11	2	42	1	14
500	2	68	1	29	2	73	1	30	2	92	1	39	2	101	1	44	2	99	1	41	2	109	1	46
600	3	14	1	57	3	20	1	59	3	43	1	70	3	54	1	75	3	52	1	72	3	63	1	77
700	3	73	1	85	3	79	1	87	3	106	1	100	4	6	1	106	4	5	1	102	4	18	1	108
800	4	19	2	1	4	27	2	3	4	57	2	18	4	71	2	25	4	69	2	21	4	84	2	28
900	4	77	2	29	4	86	2	32	5	8	2	48	5	24	2	56	5	22	2	51	5	39	2	59
1000	5	23	2	57	5	33	2	60	5	71	2	78	5	89	2	87	5	86	2	82	5	105	2	91
1100	5	82	2	85	5	92	2	89	6	22	2	109	6	42	3	6	6	39	3	0	6	59	3	10
1200	6	28	3	1	6	40	3	5	6	85	3	27	6	107	3	37	6	103	3	31	7	14	3	42
1300	6	86	3	29	6	99	3	34	7	36	3	57	7	59	3	68	7	56	3	62	7	80	3	73
1400	7	33	3	57	7	46	3	62	7	99	3	87	8	12	3	99	8	9	3	92	8	35	3	104
1500	7	91	3	86	7	105	3	90	8	50	4	5	8	77	4	18	8	73	4	11	8	101	4	24
1600	8	37	4	2	8	53	4	7	9	1	4	35	9	30	4	49	9	26	4	41	9	56	4	55
1700	8	96	4	30	9	0	4	35	9	64	4	66	9	95	4	81	9	90	4	72	10	10	4	87
1800	9	42	4	58	9	59	4	63	10	15	4	96	10	48	5	0	10	43	4	102	10	77	5	6
1900	9	100	4	86	10	6	4	92	10	78	5	14	11	0	5	31	10	108	5	21	11	31	5	38
2000	10	46	5	2	10	66	5	8	11	29	5	44	11	65	5	62	11	60	5	51	11	97	5	69
2100	10	105	5	30	11	13	5	37	11	92	5	74	12	18	5	93	12	13	5	82	12	52	5	100
2200	11	52	5	58	11	72	5	65	12	43	5	105	12	83	6	12	12	77	6	0	13	6	6	20
2300	11	110	5	86	12	19	5	93	12	106	6	23	13	36	6	43	13	30	6	31	13	73	6	51
2400	12	86	6	2	12	79	6	10	13	57	6	53	13	101	6	74	13	94	6	61	14	27	6	83
2500	13	2	6	30	13	26	6	38	14	8	6	83	14	53	6	105	14	47	6	92	14	94	7	2
2600	13	60	6	58	13	85	6	67	14	71	7	1	15	6	7	24	15	0	7	11	15	48	7	34
2700	14	7	6	86	14	32	6	95	15	22	7	32	15	71	7	55	15	64	7	41	16	3	7	65
2800	14	65	7	2	14	92	7	11	15	85	7	62	16	24	7	86	16	17	7	72	16	69	7	96
2900	15	11	7	31	15	39	7	40	16	36	7	92	16	89	8	5	16	81	7	102	17	24	8	16
3000	15	69	7	59	15	98	7	68	16	99	8	10	17	42	8	36	17	34	8	21	17	90	8	47
3100	16	16	7	87	16	45	7	97	17	50	8	40	17	106	8	67	17	98	8	51	18	44	8	79
3200	16	74	8	3	16	105	8	13	18	1	8	70	18	59	8	98	18	51	8	82	18	111	8	110
3300	17	20	8	31	17	52	8	41	18	64	8	101	19	12	9	18	19	4	9	0	19	65	9	30
3400	17	78	8	59	17	111	8	70	19	15	9	19	19	77	9	49	19	68	9	31	20	20	9	61
3500	18	25	8	87	18	58	8	98	19	78	9	49	20	30	9	80	20	21	9	61	20	86	9	92
3600	18	83	9	3	19	6	9	14	20	29	9	79	20	95	9	111	20	85	9	92	21	41	10	12
3700	19	30	9	31	19	65	9	43	20	92	9	109	21	48	10	30	21	38	10	11	21	107	10	43
3800	19	88	9	59	20	12	9	71	21	43	10	28	22	0	10	61	21	103	10	41	22	62	10	75
3900	20	35	9	87	20	71	9	100	21	106	10	58	22	65	10	92	22	55	10	72	23	16	10	106
4000	20	92	10	3	21	19	10	16	22	57	10	88	23	18	11	11	23	8	10	102	23	82	11	26
4100	21	39	10	31	21	78	10	44	23	8	11	6	23	83	11	42	23	72	11	21	24	37	11	57
4200	21	97	10	59	22	25	10	73	23	71	11	36	24	36	11	73	24	25	11	51	24	103	11	88
4300	22	44	10	88	22	85	10	101	24	22	11	67	24	101	11	104	24	89	11	82	25	58	12	8
4400	22	102	11	4	23	32	11	18	24	85	11	97	25	53	12	23	25	42	12	0	26	12	12	39
4500	23	48	11	32	23	91	11	46	25	36	12	15	26	6	12	54	25	107	12	31	26	79	12	71
4600	23	107	11	60	24	38	11	74	25	99	12	45	26	71	12	85	26	59	12	61	27	33	12	102
4700	24	53	11	85	24	98	11	103	26	50	12	75	27	24	13	4	27	12	12	92	27	100	13	22
4800	24	111	12	4	25	45	12	19	27	1	12	105	27	89	13	35	27	76	13	10	28	54	13	53
4900	25	57	12	37	25	104	12	48	27	64	13	24	28	42	13	67	28	29	13	41	29	9	13	84
5000	26	4	12	60	26	51	12	76	28	15	13	54	28	106	13	98	28	93	13	72	29	75	14	4
6000	31	27	15	5	31	84	15	24	33	85	16	20	34	83	16	72	34	67	16	41	35	67	16	94
7000	36	50	17	62	37	4	17	84	39	43	18	98	40	59	19	47	40	41	19	10	41	60	19	73
8000	41	78	20	7	42	37	20	32	45	1	21	63	46	36	22	21	46	15	21	92	47	52	22	51
9000	46	95	22	65	47	70	22	91	50	72	24	29	52	12	24	108	51	101	24	61	53	45	25	29
10000	52	6	25	8	52	102	25	39	56	30	26	107	57	100	27	83	57	74	27	31	59	37	28	7

BASIS OF CALCULATION

FLAT SEAMS EDGED ONE-QUARTER INCH

This table is calculated on a basis of $\frac{1}{4}$-inch edges on 14×20 and 20×28 sheets, consuming about 1 inch, covering a space 13×19 and 19×27 inches and exposing a surface of 247 and 513 square inches respectively.

FLAT SEAMS EDGED THREE-EIGHTS INCH

This table is calculated on a basis of $\frac{3}{8}$-inch edges on 14×20 and 20×28 sheets, consuming $1\frac{1}{8}$ inches, covering a space $12\frac{7}{8}\times18\frac{7}{8}$ and $18\frac{7}{8}\times26\frac{7}{8}$ inches and exposing a surface of $243\frac{1}{64}$ and $507\frac{17}{64}$ square inches respectively.

STANDING SEAM, SINGLE LOCK

This table is calculated on the basis of $\frac{3}{8}$-inch single lock cross seams, consuming $1\frac{1}{8}$ inches of tin and covering $228\frac{17}{32}$ square inches when edged 1 and $1\frac{1}{4}$ inches and giving a finished seam $\frac{3}{4}$ inch high, and covering $222\frac{3}{32}$ square inches when edged $1\frac{1}{4}$ and $1\frac{1}{2}$ inches and giving a finished seam 1 inch high, with 14×20 tin. With 20×28 tin edged in the same way with a $\frac{3}{4}$-inch finished seam $477\frac{1}{32}$ square inches are covered, and with a 1-inch finished seam $463\frac{19}{32}$ square inches are covered.

STANDING SEAM, DOUBLE LOCK

This table is calculated on the basis of the amount of tin consumed by double lock machines, which is $1\frac{7}{16}$ inches by measurement for cross seams and covering $222\frac{63}{64}$ square inches when edged 1 and $1\frac{1}{4}$ inches and giving a finished seam $\frac{3}{4}$ inch high, and covering $216\frac{45}{64}$ square inches when edged $1\frac{1}{4}$ and $1\frac{1}{2}$ inches, giving a finished seam 1 inch high, with 14×20 tin. With 20×28 tin edged in the same way with a $\frac{3}{4}$-inch finished seam $471\frac{31}{64}$ square inches are covered, and with a 1-inch finished seam $458\frac{13}{64}$ square inches are covered.

DIRECTIONS FOR USE

Look for the number of squares nearest the required surface. Note the quantity of tin opposite in the column for the kind of roof to be put on, whether it be **1-4 inch or 3-8 inch Flat Seam or 3-4 inch or 1 inch Standing Seam, Single Lock or Double Lock,** and set down the amount. Then, in the same manner, determine the quantity of tin for the odd feet and add this to the former amount. Reduce the sheets to boxes by dividing by 112.

FLAT SEAM EXAMPLE

How much 14×20 tin edged ¼ inch covering 13×19 will be required to cover a roof 4,665 square feet flat seam?

First look for 4,600 square feet (=46 squares) and set down the quantity opposite, thus:

	23 boxes 107 sheets
Then for 65 square feet and set down	38 sheets
Making a total of	23 boxes 145 sheets

which is equal to 24 boxes 33 sheets.

SINGLE LOCK STANDING SEAM EXAMPLE

How much 14×20 tin will be required to cover a roof of 3,752 square feet with single lock cross seams and 1-inch standing seams?

First look for 3,700 square feet (=37 squares) and set down the quantity opposite, thus:

	21 boxes 48 sheets
Then for 52 square feet and set down	34 sheets
Making a total of	21 boxes 82 sheets

DOUBLE LOCK STANDING SEAM EXAMPLE

How much 20×28 tin will be required to cover a roof of 2,987 square feet with double lock cross seams and ¾-inch standing seams?

First look for 2,900 square feet (=29 squares) and set down the quantity opposite, thus:

	7 boxes 102 sheets
Then look for 87 square feet and set down	27 sheets
Making a total of	7 boxes 129 sheets

Dividing 129 by 112, they are found to be equal to 1 box and 17 sheets, which added to 7 boxes

Give a total of	8 boxes 17 sheets

RUNNING A TIN ROOF OVER A FIRE WALL

In the accompanying illustration, Fig. 104, are shown the methods of lining the fire walls and connecting them to the main roof and to the cornice roof. Let A B C represent the cornice roof, fire wall and main roof respectively, and D E and F the sheathing line. Now, assuming that the tinning has been started below G, the courses are carried as far as H, when the distance is measured from H to I. A regular strip is now laid out, soldering the short seams, before bending up to the required width H I, after which it is locked into the lock H, and will appear as shown by J K. The courses L M N, etc., are laid in the regular manner, as on the flat roof, leaving the last course N to project over the cornice roof, as shown by O. If the fire wall is level all round the projecting tin plate O is turned over on the cornice roof with a mallet, as shown by the dotted line P. The course R S, etc., are again laid in the regular manner, cutting off the last course S to within an inch of the line of the cornice, as shown at T; this allows for turning over and nailing.

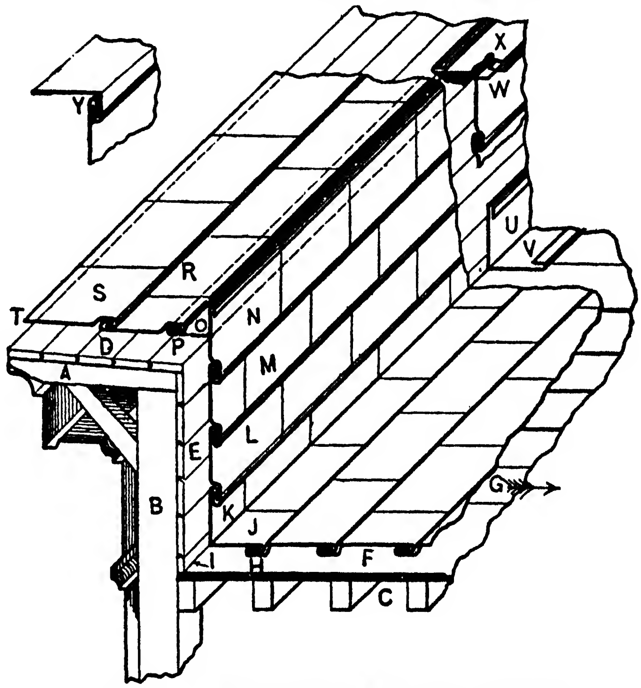


Fig. 104. Sectional View of Cornice and Roof

If the fire wall shown in the sketch was the back of the roof against which the water would run, then a valley flashing would have to be put in first, as shown by U V, which allows the water to run over and not against the seam. If the fire wall was unequal in hight and the tin was to be turned over the cornice roof as just described, we would not be able to obtain a straight course on the cornice roof. To obtain a straight course in this case the last course N could be flanged out 1 inch, as shown at W, after which the top courses are laid as shown at X, which are afterward turned down and double seamed, as shown at Y. The cornice roof is now soldered, being careful to solder down the fire wall about 4 inches, while on the main roof the strips against the fire walls where the joints are made should be soldered up about 8 inches. The seams on the fire wall are left unsoldered and

are made water tight by painting them, before they are malleted down, with a good thick coat of white lead in oil, after which they are tightly closed with the mallet and then "white leaded" again. Assuming that the fire wall was of brick, stone or terra cotta, the same rule is observed for covering, except that the fire wall is covered with standing seam, locked into the strip K at the bottom and double seamed as at W X and Y at the top.

A roof covered with IC terne plate will make a good roof, but certainly not as good as IX tin, because the IX is heavily coated and of thicker gauge metal and will or ought to outlast the IC brand.

JOINING A COPPER CORNICE WITH A TIN ROOF

For buildings of a first-class character, there is a growing demand for copper cornices, in many cases the roof being of tile or concrete. In some instances, however, the cornice maker is called upon to connect the copper cornice with a tin roof, and all who have had experience with the use of copper in connection with tin roofing plate are aware of the action which takes place between the two metals when exposed to the atmosphere, which results eventually in destroying the tin plate. It is remarkable how quickly the tin plate can be destroyed on occasion, though in some cases no disadvantage has resulted from the connection for a considerable time. In order to prevent, as far as possible, the destruction of the tin plate, use an oil burlap or canvas between the two metals, as shown in the accompanying view, Fig. 105.

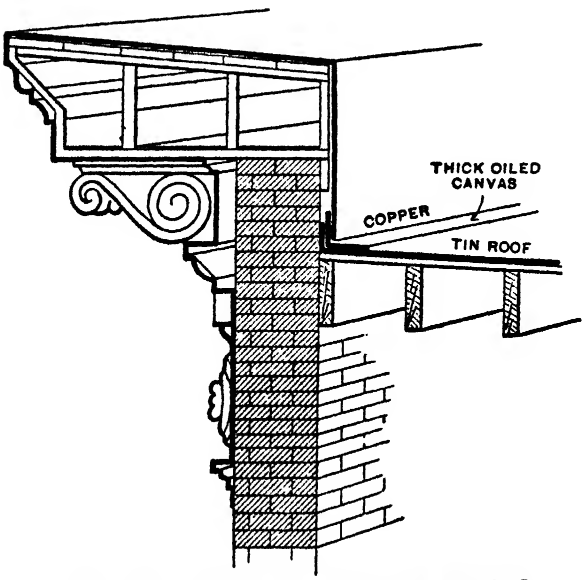


Fig. 105. Sectional View Showing Method of Applying the Canvas

Make it a point to run the flashing from the tin roof up behind the copper for a considerable hight and fasten it securely to the battlement. This portion of the tin work is given a heavy coat of good paint. Over this is placed a piece of oiled canvas running up above the tin flashing and extending down on the roof so

that the copper of the cornice cannot possibly come in contact with it. After the oiled canvas is in place it is also given a coat of paint and the copper work fastened to the battlement in a secure manner. It has been proved by experience that the use of the oiled canvas, even in other methods of connecting the tin and copper, has greatly prolonged the life of the tin plate.

A FEW REMARKS ABOUT FLASHINGS

Flashings are of vital importance in roof construction. It is seldom that a leak occurs in the clear body, or surface, of a roof, be it of tin, slate, tile, or composition. In most cases, the leaks are in connection with the flashings, or finish around uprising walls, chimneys, pipes or other structures. To thoroughly describe and illustrate all the various forms of flashings would require so much time and space that it will be necessary to dismiss the subject with a few general remarks upon principles.

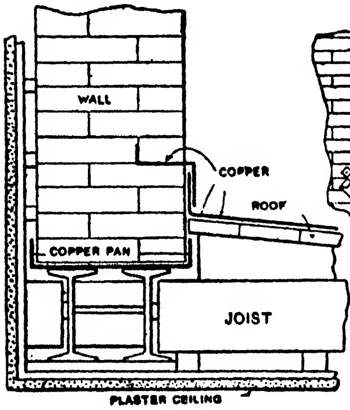


Fig. 107

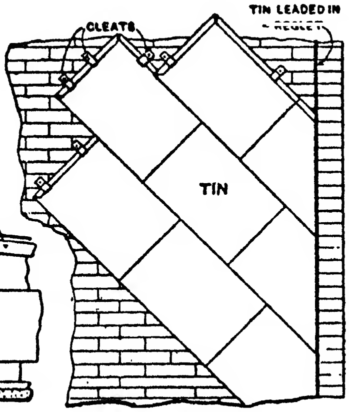


Fig. 106

The best material for use in flashings is sheet lead; the next is copper, then zinc, tin and galvanized iron, in the order named. The same piece of flashing should never be attached to both roof and wall. The flashing should be in two parts—namely, the "under flashing," which is lapped on and nailed, locked or soldered to the roof and turned up against the wall or rising surface, and the "cap flashing," which is built in, let in or secured to rising wall or surface, and which laps down over the upturned part of the under flashing.

The reason for avoiding the use of flashing made of one piece, permanently attached to both roof and wall, is that the uneven settling of the roof and wall, or the relative difference in the expansion and contraction of the roof and wall, will inevitably injure the connection between the flashings and the wall, or the roof, as it is strained between the two contending forces; whereas, if the flashing is in two parts, one attached to the roof and the other to the wall, and connected by an

adjustable lap only, ample provision is made for the independent movement of both roof and wall without injury to the flashing.

The hight of flashing and the depth it should extend in the wall are matters of latitude. What would be a matter of first-class flashing in New Orleans would prove entirely inadequate in Boston. Ignoring wind, a Southern roof seldom has anything more serious to take care of than rain water, the gutters and conductors, being free of obstruction, allowing the water to drain off as fast as it falls; whereas, a Northern roof is liable to have its outlets clogged with ice, and water to accumulate until the roof is, in effect, a small lake. Or snow will drift and ice form at the junction of the roof and the wall, forming obstructions that will lead the water over the top of the under flashing, if it does not extend well up against the wall.

In New England, the winter rains are driven, or soak, entirely through exposed 12-inch walls if the bricks are not of good material and thoroughly burned. The writer knows of a number of instances in Boston where it was necessary to entirely cover exposed party walls with tin, from the ground to the roof, the tin being laid flat lock, secured with cleats, and the sheets laid "diamond style," leaving the seams at an angle of 45 degrees, as shown in Fig. 106, thus avoiding all vertical seams.

The method of providing for the water that soaks into an ordinary wall that is exposed to a considerable sweep of the wind and is pierced by an opening for a bay window is shown in Fig. 107, the opening being spanned by I-beams which carry the wall. In addition to the flashing shown, copper pans of the same length as the beams, about 1 inch wider than the thickness of the wall and 2 inches deep, are set on the top of the beams and the wall is built in the pan. Drains are provided at each end of the pan to carry off the water as it soaks through the wall into the pan. But for these pans the ceiling of the bay window would, in wet weather, be constantly dripping when the direction of the wind is such as to drive the rain against the wall.

On high grade jobs such as churches, under the copings and sills of the windows, etc., it is advisable to place copper, inasmuch as, in the majority of cases, these sills, coping and the like are of a porous stone permitting the percolation of water which often times finds its way into the building, giving the impression that the roof leaks and entailing an expensive controversy between either the architect or the owner, and the roofing contractor. It is, however, well to bear in mind that, unless cap flashing was built in during the construction of the wall, even, in which case it would be advisable to see that the joint is thoroughly cemented, the paintskinning of the joint should be done with extreme care, packing it in until it oozes out.

COPPER FLASHING ON THE MODERN FIREPROOF BUILDING

On modern fireproof buildings the roof is either supported on terra cotta or reinforced concrete arches. A cinder concrete fill is placed on these arches; and as arches are level throughout, this fill is graded to the outlets.

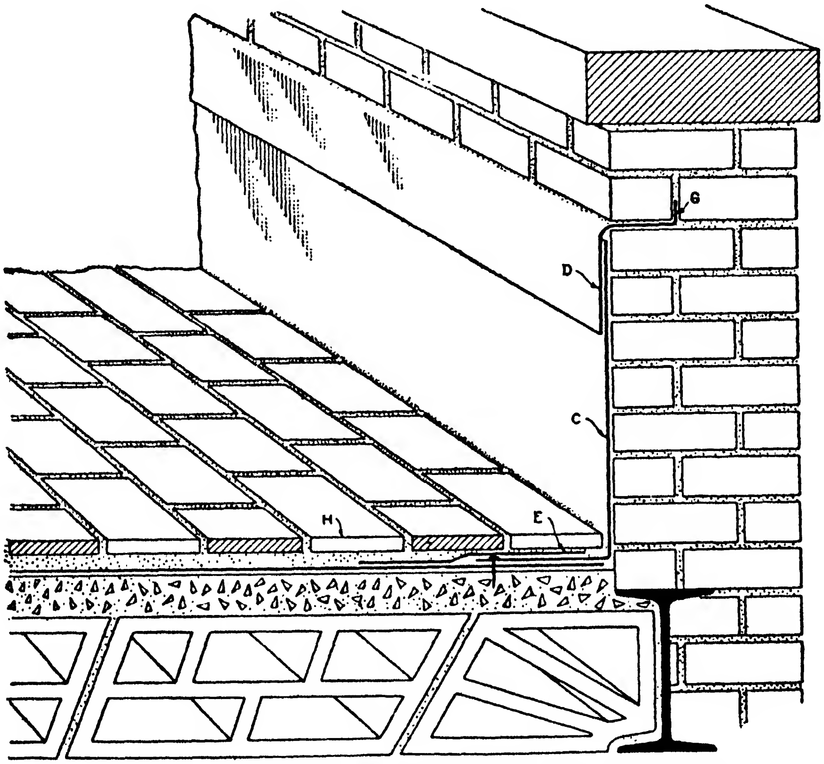


Fig. 108. Copper Flashing on the Modern Fireproof Building

On this fill five ply, more or less, of waterproofing is applied. Then the copper flashing C, Fig. 108, is fitted and nailed in place. As the cap flashing D was built in the wall it is necessary to raise it a little, so that base flashing C may be slipped under the cap flashing. This cap flashing is dressed back with a piece of smooth board about a foot long and nailed to another stick for a handle, which is used like a mallet. It is to be noted that the edge G of the cap flashing is turned upward in the wall; this secures the cap to wall and is required on most public buildings.

The waterproofing men lay a felt strip, swabbing it with tar, over the nails of the base flashing at E and coat entire roof with a generous amount of tar.

Bricklayers can now lay the flat tile roof H in this manner. They first spread the cement (sand and Portland cement) over a small area, then, just as in bricklaying, they set their tiles. After all the tiles have been laid a thin grout of cement is broomed over the tiles filling in the joints.

FLASHINGS FOR SLATE OR SHINGLE ROOFS

In Fig. 109 A is the roof surface, B the side or gable wall and C D the half round hanging gutter, which last should be flashed up under the shingles or slates at least 8 inches, as indicated by the dotted line E F, and against the end of the gable wall, as at G. A corner flashing should be joined to G and E E, as shown by the dotted line E^1, on the side of the wall. This being done, the braces H I, etc., are fastened to the front of the gutter and screwed to the roof board.

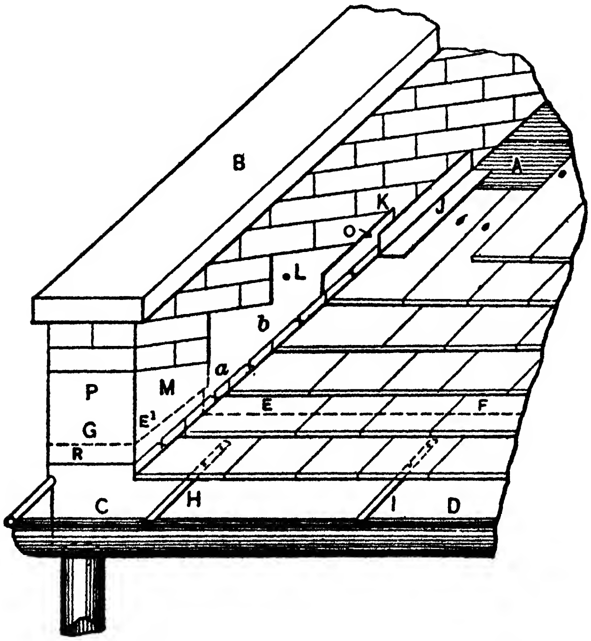


Fig. 109. Putting in Step and Counter or Cap Flashing for Shingle or Slate Roof

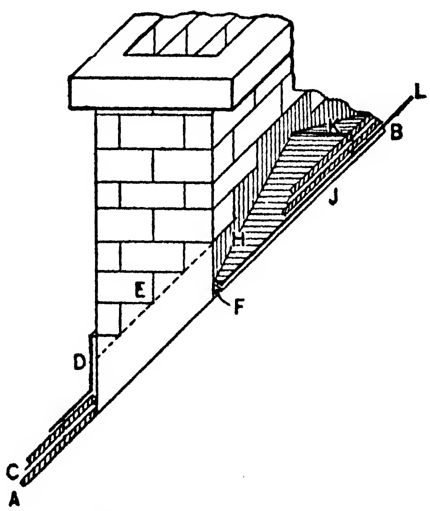


Fig. 110. Flashing Around a Chimney on a Shingle Roof, Showing Cant Board in Rear

The slater or shingler then lays his eave course, the tinner furnishing him with shingle flashings, which are made of tin and painted before being applied. They are to be bent up 2½ inches on each side and in length 2½ inches more than the slates or shingles are laid to the weather.

The shingle flashing is laid on the eave course and over the same. The courses are then laid in order, the flashings being put in with every course, as indicated by X X, etc., or as is better shown at J, which illustrates the flashing overlapping the previous flashing K, the bottom O of the flashing J running within ½ inch of the bottom line of the slate or shingle R.

When the roof has been covered the tinner puts on the counter or cap flashing L M, flashing into the joints of the brick work and continued around the end of the brick wall P, overlapping the shingle and gutter flashings. If desired the cap flashing can be made in small pieces, having seams at *a* and *b*, which saves material.

Fig. 110 shows the flashing just around a chimney or other structure passing through the roof, where the covering is slate, tile or shingle. This method also applies to metal roofs, with the exception that the flashing is locked and soldered on the metal roofing, while in this case it is flashed over and under the roof covering of slate or shingle.

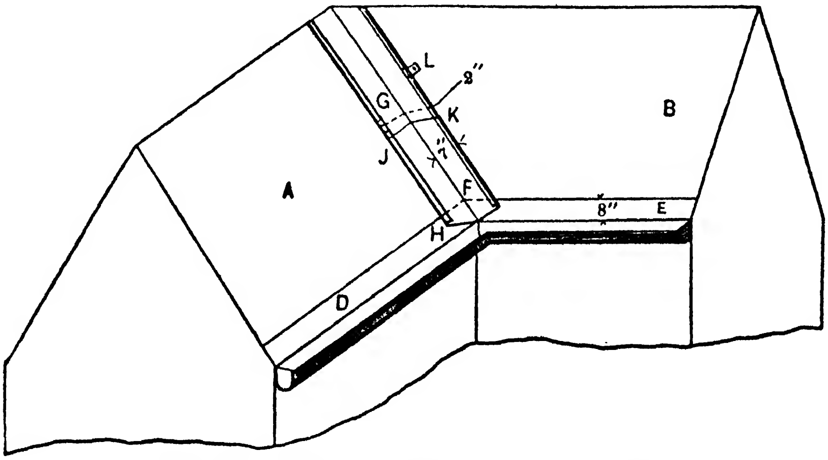


Fig. 111. Laying a Valley on a Pitched Roof

Referring to the diagram, A B represents the line of the roof, and C the last course of slate or shingle, butting against the bottom of the chimney. The flashing D is now put in, the lower flange being made wide enough to cover the nail heads, and the top is flanged into the joints of the brick work. The roof covering being continued, the side flashing E is put in, using shingle and cap flashing, in the same manner as described in connection with Fig. 109.

When the back of the chimney is reached a cant board or saddle is put in by the carpenter, in order to throw the water to either side. This board is then covered with metal, as shown by H K, stepping into the brick joints and flanging upward on the roof at least 18 inches above the top of the saddle K, to prevent any leaks resulting from a snow storm. A chimney in a roof, as illustrated, always

forms a pocket when the snow slides; and if the flange F J L is not carried high enough the snow in melting will suck under the flashing and cause a bad leak.

A valley is put in on a pitched roof, the covering of which is not of metal as shown in Fig. 110, A and B representing the roof surface; D and E, the gutter, flanged on the roof 8 in. and F G the valley, flanging 7 in. on the roof each side, and having a water lock or drip H and I. The valley is laid from the bottom up, overlapping the gutter flanges, as at H and I, if it is laid in lengths as is usual say from 8 to 10 ft. the joint should be overlapped 2 in. as at J K, running the valley to the top of the ridge. Care must be taken in fastening the valley not to nail through it. Otherwise a leak will occur. Cleats should be used as at L, so that when the slates or shingles are laid over the valley and the water flows down the lock prevents the water from going sideways and causing a leak, whereas if nails were driven direct into the valley a leak would occur at once.

PLACING BLOCKS ON ROOFS TO WHICH ARE FASTENED PLATFORMS, BRACING RODS, ETC.

In Fig. 112 is shown a piece of joist called blocks, covered with tin or other metal, the joist being cut to any desired hight. In this case it is 3×4, and 8 inches in hight. A flange 1 inch in width projects all around the bottom of block, as shown in Fig. 112, and is used to solder water tight to the roof. The dotted line shown at the side at B, and top at A, indicates how the laps are placed, and over the top of the laps, as shown at A, a piece of metal is soldered water tight. These blocks are now set in their proper positions on the metal roof, say about 6 feet apart, and soldered water tight to the tin or galvanized iron roof. This keeps the water from soaking under the block and rusting out the metal roof. After all of the blocks have been properly placed, cross joists are set on top of same. Then spruce strips of $1\frac{1}{4} \times 3$ inches in thickness are nailed at right angles to the cross joists not over 2 inches apart. In making the platform it should be made in such sections that it can be easily removed in case the roof needs repairing or painting. If the roof was very large quite a number of blocks would be required, and as there may be some objection to the expense of covering the blocks, Fig. 113 shows how the covering could be avoided. A in Fig. 113 represents the wooden block of the same size as shown in Fig. 112. If the wooden blocks were set direct upon the

tin or galvanized iron roofs it would be found after each rain, even after the roof was dry, that it would be quite wet between the wooden block and metal roof, because the air could not circulate, and in time the tin or galvanized iron would be rusted through. Therefore, to avoid the rusting of the tin or galvanized iron, and still not cover the blocks, proceed as follows: In Fig. 113 B represents a piece of 18 ounce sheet copper tinned on both sides, projecting 2 to 3 inches all around the entire block, as shown in Fig. 113, and is then soldered water tight to the roof. On top of this sheet copper the wooden block is set. The water soaking between the wooden block and sheet copper would have no effect in destroying the copper, as would be the case if placed direct upon the tin or galvanized iron, as before explained. The sheet copper is tinned on both sides, so as to avoid any

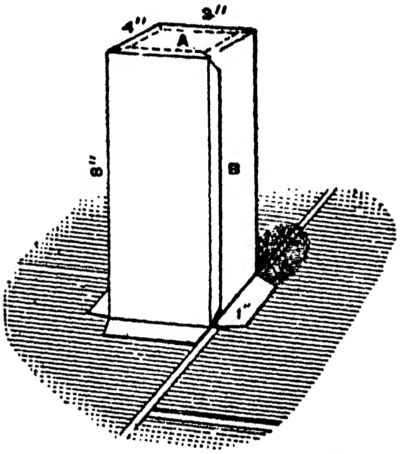


Fig. 112. Showing Block Covered with Tin

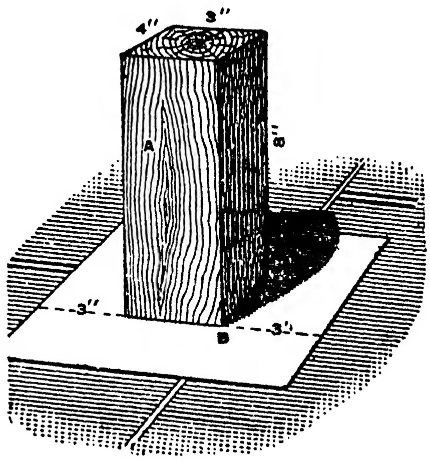


Fig. 118. Showing Block Resting on Sheet Copper

electrical action between the two metals that would eventually destroy the tin or galvanized iron.

The method first described is often used as a means to fasten stay rods, etc., for various purposes, such as a brace for signs, smoke stacks, and the like.

A block is first nailed to the roof and then covered as explained, and then the rod is secured to the top of this block in a bed of white lead.

In many cases on steep roofs there is a chimney at the eaves; and to provide a perfect draft, the chimney is built quite high—sufficiently so, to have its top above the ridge of the roof. In this case the chimney is braced by passing a wrought iron belt around it, about midway, and guyed to the roof with stiff rods. The rods are higher at the roof end than at the chimney and are simply flashed with sheet metal for, say a distance of six inches, inasmuch as any water on the rod would flow away from the roof.

SHEET LEAD FOR ROOF FLASHINGS

A knowledge of how to properly handle sheet lead is of considerable value to any roofer who has anything to do with the work on many of the artistic suburban and country homes now being built. Flashings are necessary, but when unduly prominent are objectionable features in the architecture of a building, and the nature of lead is such that it can be satisfactorily used where harder metals can not with any degree of neatness, as on a round tower, for instance.

Straggling, prominent flashings and aprons which attract the eye to various chimneys, instead of to the more important parts of the house, are not likely to

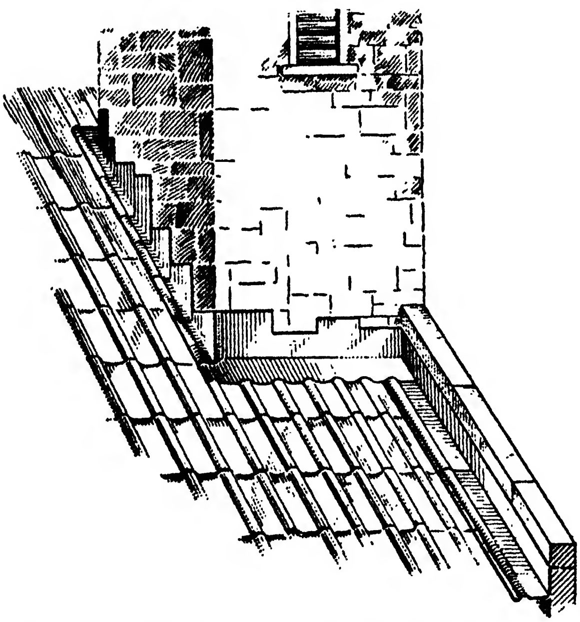


Fig. 114. Unattractive and Conspicuous Appearance of Lead Flashings Let Into Irregular Joints in Stonework

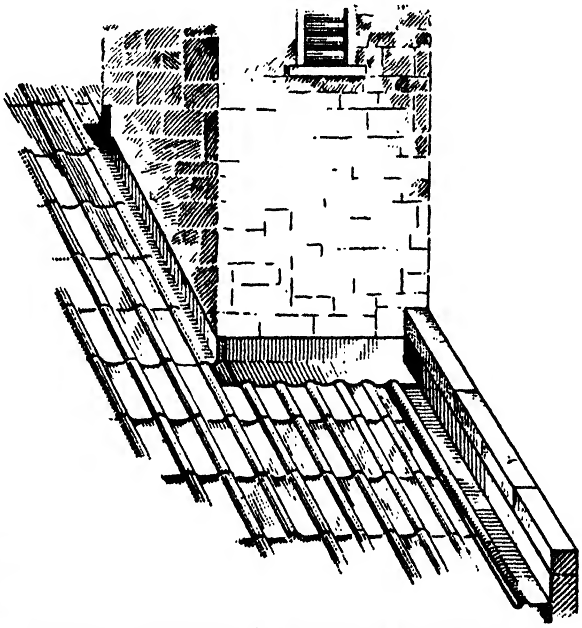


Fig. 115. Neat and Inconspicuous Appearance of Lead Flashings Let Into Groove in Stonework

meet with favor from the owner or designer, however well they may serve their purpose. The use of lead will often make all the difference between success and failure in getting a desired effect.

The workman who has not had an opportunity of learning how to handle this material, however, will probably not be any more successful than if he had used tin. This may be seen in the job shown in Fig. 114, which is a tower on a church recently built, with lead flashings around it put on in such a manner that they are the most prominent features of the roof. The roof is of red tile and the stone of tower is laid in irregular courses, the blocks being of somewhat large size.

The flashings have been put on piece by piece with the sections of tile, and the upstands have been fixed into the nearest vertical and horizontal joints. These being at irregular hights and sometimes 12 to 14 in. above the roof, give the whole job a patchy appearance. The battered and wrinkled lead at the corners, due to inexperience of the man who laid it, does not make it look any better, and this part contrasts unfavorably with the excellent workmanship on the rest of the building. By laying the lead on the plan shown in Fig. 115 a much superior job would have been obtained, and it would have been inconspicuous. The nature of the building stone will not always admit of turning the upstands into cut grooves or "raglets," but in this case it would.

Where a very hard stone is used the upstands are sometimes set up as shown in Fig. 116 and fixed with spikes to convenient joints. The head turned on the upstand about 1 in. from the upper edge provides a rest for the cement pointing, and this also covers the spikes used in fastening.

In laying lead flashings, as shown in Fig. 115, the lead is cut into strips of the desired width, say 12 in., and dressed flat on a smooth plank. A groove or raglet about 1 in. deep and $\frac{3}{4}$ in. wide having been cut in the stonework 5 in. up from the roof, and the point under the cap stone having been cleaned out to a similar depth, work is commenced at the eaves and carried upwards.

A bead is turned on the side of the strip of lead by dressing over the straight edge of a plank. This is shown at B in Fig. 117. This is to fit into the joint and raglets, so that a water-tight joint will be made when pointed and also to provide fastening. Whatever hight may have been decided on or is necessary, 5 in. more or less below this head, the lead is dressed over and carried to its position, where it is carefully dressed into place and the head set back in its groove. It is there firmly fastened by driving the lead wedges in and calking them. The wedges may be made from strips of lead tightly rolled, and about 1 in. wide.

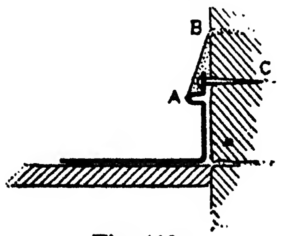


Fig. 116

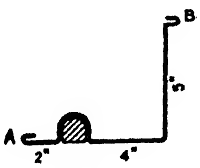


Fig. 117

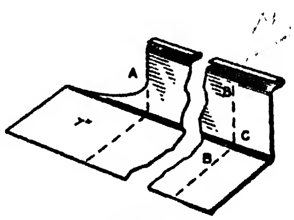


Fig. 118

DETAILS OF FORMING LEAD FLASHINGS

The side flashing is turned up about 1 in. on reaching the breast of the tower by beating up the lead into a "corner." The breast flashing is set up similar to the side flashing except that it is not turned over square, but to suit the pitch of

the roof. Then at the cap-stone end it is turned up 5 in. and another outside corner worked on it. When this has been completed and squared up neatly to fit the angle the piece is fastened in position. It must be allowed to project from 5 to 7 in. by the tower and a portion of the upstand is cut as shown at A in Fig. 118 to admit of being dressed closely down.

The tower side flashing is then put on in a similar manner and stopped at the floor of the gutter behind the tower. It can also be laid in the manner shown in Figs. 117 and 119. This is fitted under the tile or slate and has a roll formed about 3 or 4 in. from the wall, which prevents the water from the gutter spreading. This side flashing 3 in Fig. 119, comes out on top of the tile or slate at the breast line of the tower and continues to the lower edge of the breast flashing as cover, the roll

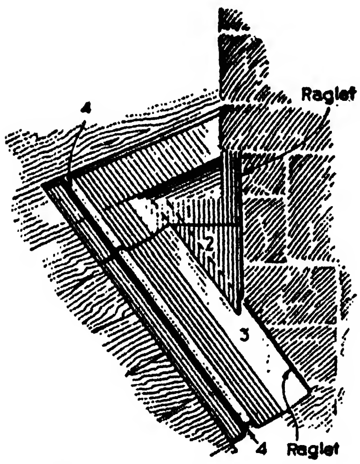


Fig. 119. Flashing at Top

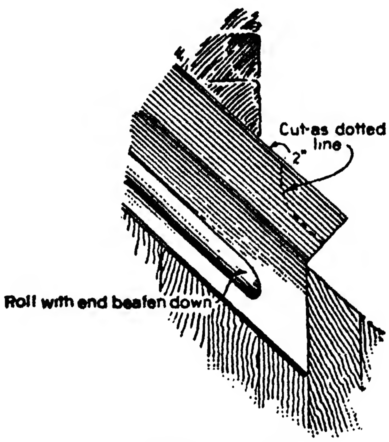


Fig. 120. Flashing at Bottom

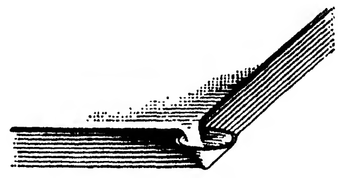


Fig. 121. Pig Ears

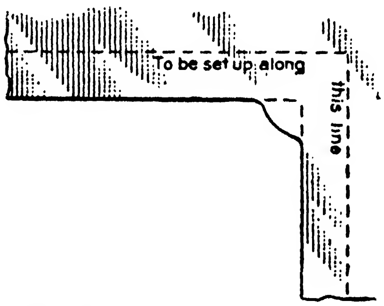


Fig. 122. Pattern of Flashing

4 being stopped at the line of stone and the lead beaten down over a rounded end as shown in Fig. 120. The upstand is worked around the face of the tower about 3 in. and neatly trimmed off. Before working this upstand it should be cut as shown by the dotted line in Fig. 120. This allows it to come down with less chance of thinning and tearing the lead.

The upper end of this flashing is finished by beating the roll down flat at the level of the gutter floor or a little above it, and the lead in the gutter is allowed to project so that when beaten down it will make a complete cover across the flat part of the side flashing. This corner must also be cut out before commencing to beat it down, leaving sufficient to cover well the vertical part when it has been beaten back. The corner must be kept round until it is almost completed, then it can be squared up, care being taken to avoid tearing.

The upper edge of the lead in the gutter on the roof side should be set up half an inch and a fillet of wood of triangular section nailed behind it to carry the weight of the tile or slate. The tile may fit closely over the roll on the side flashing, or if slate is used a fillet nailed down the side will tilt the slates and butt the edges against the roll, leaving a clear waterway from the gutter.

The wall upstand of the gutter may be turned into the raglet if not very long, or an apron may be fitted over it and fixed in the same manner. This is to allow of movement in expansion and contraction. Binding firmly on all sides will lead to trouble through the permanent enlargement of the metal by expansion forming bulges and, eventually, cracks.

A gutter behind a chimney might have each end dressed down to a side flashing as shown or have one end open and the other set up against a wall or stone cap as in this case. This entails the working of two outside corners on the gutter and the method of doing so may be briefly explained here. The lead having been marked off at the correct floor lines of the gutter, is set up to its proper angle.

On setting up the end upstand two wide pig ears are formed as shown in Fig. 121. Holding a pear-shaped mallet inside the pig ear the lead is gradually drawn up from the corner. A round dresser or bossing stick is used for this, the strokes tending upward to draw the lead up and outward to dispense with the extra thickness caused by contracting the lead at the angle. Keep the corner round until the correct pitch has been gained. Only when it has reached this must it be squared up.

To work an inside corner cut the lead as shown in Fig. 122 and use the round dresser with inward tending strokes, as the tendency is for the lead to thin and tear at the corner. Draw the lead towards the corner by bulging out the upstand and dressing towards the corner against a flat piece of wood, and do not attempt to square the angle until it has been worked into the correct position. Do not rush, either, too much, as nothing will be gained, and do not let the lead form into wrinkles. Dress these out immediately if they appear.

Nails should never be driven through lead where exposed to the weather, as the lead soon loosens up around them. Where flashings lap, tails should be left on the lower sheet when trimming and dressed over the upper to prevent blowing up. Use clips for fasteners instead of nails, and use only wooden tools to work lead, as a hammer will cut into and seriously impair its life.

Lead of fair weight, 5 or 6 lb., will last a very long time if properly laid, as it is practically proof against corrosion from acids contained in soot, etc., and quickly forms an oxydized surface that effectually protects it from the influence of the weather.

COPPER SIDING FOR PENT HOUSES

On practically every building of fireproof construction there are on the roof smaller structures known as bulkhead or pent houses for the housing of elevator machinery, tanks, etc. Perhaps one or two additional stories are built above the roof line of the building proper and the pent-house method of construction is employed by reason of the lightness of material, as it adds but the minimum of weight to the steel structure and foundation.

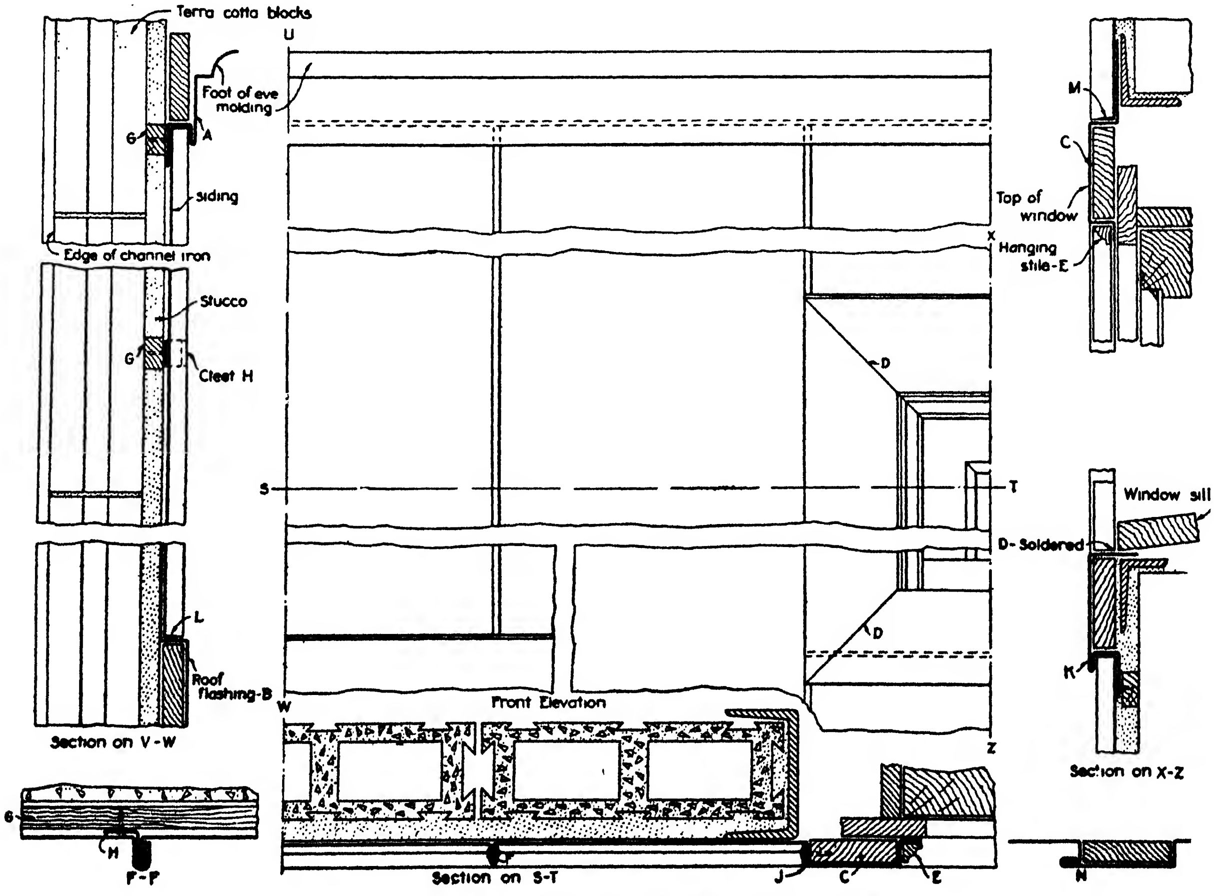


Fig. 123. Details of Copper Siding for a Pent House

The scheme of construction makes use of a structural steel framework, with terra cotta blocks for the walls. To prevent the ingress of the elements, sheet metal is utilized for exterior finish. As this is a story of the siding, the many details of eave finish, flashing, etc., may be passed over, except to say the eave generally has some sort of cornice molding, perhaps just a molded hanging gutter.

The sheet metal contractor has nothing to do with the structural details, but as it is practically impossible to attach the siding to the terra cotta blocks, he should reason with the architect and insist on a proper surface and wood grounds to nail cleats to, Fig. 123. The modern method of obtaining a true surface is to secure boards to the terra cotta at the base of the wall for the flashing B, which connects with the main roof of the building.

A board at the lock of the eave molding A, together with a furring strip ground, is provided as shown. The furring strip grounds are spaced about 2 feet from base to eave to nail cleats to for holding the siding. The entire surface is plastered flush with the wood grounds. Likewise around all windows and doors a board is fastened as indicated by C, to which is attached the sheet metal casing. There is a similar provision at corners of pent houses.

As it is usually imperative to make buildings weather tight as quickly as possible, the flashing, eave moldings, etc., are set long before the siding, for this can be done when the need of the other work is not so pressing. Hence to facilitate the applying of the siding a pocket is made in the bottom of eave molding, as at A. The siding is cut to average 18 inches from seam to seam. This seam is the single and double standing edge style as shown at F. At F F is a horizontal section of the seam to show the cleat H nailed to woodground G.

When the siding connects with the window or door casing, it has a single edge as at J. At all pockets, A and K, an edge is bent on the siding the same width as the standing seam. At the flashing B and at the top of windows or doors a ¼-inch edge is turned out and soldered to the flashing, as shown, for example, at the top of windows or doors at M. The siding over windows and doors is erected after casings are put on. The siding is crimped to obviate buckles as much as possible, while the casing is plain metal. When siding up to windows and doors has been erected, the casing is fitted and put in place, beginning with the sill, then the sides and last the top. The sill is soldered and also the miters D. Carpenters can now renail into place the hanging stile E. The windows and doors are of wood covered with copper or perhaps hollow metal.

If it is desired that no nails show as at J, for instance, then the method shown at N can be employed; also the double seam, as in tin roofing, can be used for siding having cleats to keep the siding in place.

If the hight from the roof flashing to the eave pocket is such as to require a cross seam in the siding, the flat seam like that used in flat-seam tin roofing is used and soldered on the back before erecting.

FLASHING LARGE SMOKE STACKS AND FLAG POLES

The method of flashing large smoke stacks and flag poles, etc., is shown in Fig. 124, where A B represents the roof, C the smoke pipe, D D the roof flange, and E E the vertical collar soldered to the roof flange around *b* C. Care should be taken that the collar is a trifle larger than the pipe, which allows the pipe to move without breaking the joint between the collar and the flange. The hight of the collar E at the highest point of the roof should be not less than 8 inches, and overlapping this collar a flaring apron, F F, is set, as shown, overlapping the collar about 4 inches. To hold this apron in position a flange shown at *a a* rests on the ring H H, which is made in two halves from 3-16×1 inch band iron, as shown in Fig. 125, in which the inner circle represents the pipe, around which the ring H H is bolted at J J. This ring should be made a trifle smaller than the pipe, so that

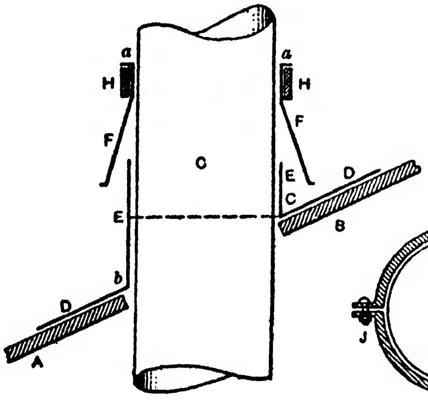


Fig. 124. Method of Flashing

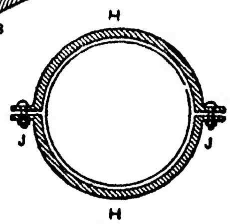


Fig. 125. The Ring

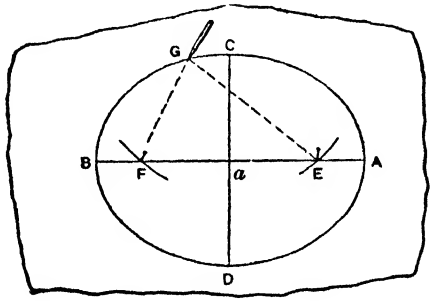


Fig. 126. Method of Obtaining Roof Range

when the flaring apron is placed inside of same, and the bolts fastened, it will secure the flange of the apron tightly against the pipe. Before fastening the band roofing cement is placed between the apron flange, band iron ring and pipe, which makes a tight job when the bolts are fastened.

The method of obtaining the opening in the roof flange D D, in Fig. 124, is shown in Fig. 125, which can be accomplished without the use of a draughting board, as follows: First draw the line A B equal to the slant opening *b* C in Fig. 124. Bisect A B in Fig. 126 and obtain *a*. Through *a* draw the vertical line C D, making *a* C and *a* D each equal to one-half the horizontal distance E C, in Fig. 124. Take the distance B *a*, in Fig 126, in the dividers, and with C as center intersect B A at F and E, through which points drive a nail as shown. Fasten the ends of a piece of spool wire to the nails, making the loop as long, so that when a

pencil or prick punch draws the wire taut the point will meet C. With the pencil G in position describe the ellipse as shown. Allow 8 in. around the ellipse for the flange D D, in Fig. 124, which acts as a roof flashing.

PATTERN FOR A ROOF FLANGE

In the accompanying illustration, Fig. 127, are shown the principles employed in obtaining a roof flange for a round pipe, the roof having an angle of 45 degrees. In this connection it may be proper to remark that no matter what may be the shape of the pipe, or what the pitch of the roof, the principles described are applicable to any case, whether the flanges are made of copper, zinc, galvanized iron, tin or sheet lead. Referring to the illustration, let A B represent the pitch of the roof and C D E F the round pipe fitting on it. In its proper position above the pipe place the profile, as shown, which divide into equal spaces, as indicated by the small figures 1 to 5. From these small figures, at right angles to 1 5, drop lines intersecting the roof line A B, as shown.

From these intersections and at right angles to A B draw lines indefinitely, as shown. Now parallel to A B draw the line 1° 5°.

Now, measuring in each instance from the line 1 5 in the profile, take the various distances to points 2, 3 and 4 or 2′, 3′ and 4′, and place them on similar numbered lines in the pattern, measuring in every instance from the line 1° 5°, thus obtaining points 2, 3 and 4 or 2′, 3′ and 4′. A line traced through these points, as shown by the shaded portion, will be the pattern for the opening to receive the pipe. The width of the flange, however, will vary according to the style of roof in use. If the roof is of metal, which allows soldering, a flange of 2 inches all around is sufficient, while if the roof is slate, tile or shingle an 8-inch flange is usually made. The flange is obtained by simply setting the dividers to the desired width and scribing around the opening, as is shown by G H I J.

For the pattern for the pipe mitering on the roof A B, extend the line D E of the pipe, as shown by D K, upon which place the stretchout of the profile of the pipe, as shown by the small figures on D K, at right angles to which and from these small figures draw lines indefinitely, as shown, which intersect with lines drawn at right angles to E F from intersections on A B. A line traced through intersections thus obtained, as shown by L M N O, will be the desired pattern, the

seam being placed on E F to avoid leakage. In diagram P is shown the method of flanging the pipe and flange. R R shows the edge turned upward on the flange,

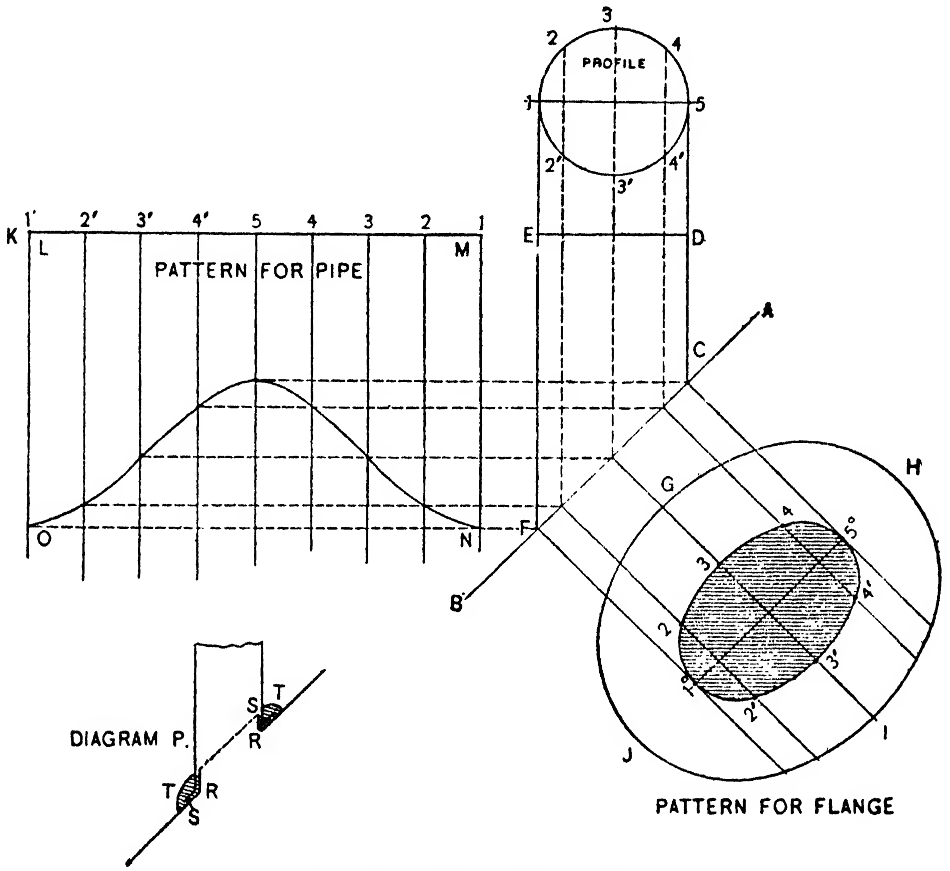


Fig. 127. Making Roof Flanges

while S S shows the edge turned outward on the pipe. The flange and pipe fit snugly and are then "sweated" with solder, as shown by T T, which completes the job

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COLLAR AND FLANGE FOR SMOKE STACK

There are various methods of constructing the connection between a smoke stack and roof. It is, of course, necessary to make the connection weather proof, but in addition to this it should permit of ventilation or provide for a circulation of air between the hot stack and the roof boards. There should be no rigid connec-

tion between the stack and roof, as the vibration of the stack would break seams and cause leaks. The opening in the roof should be at least 8 inches larger in diameter than the stack if the roof is of wood construction.

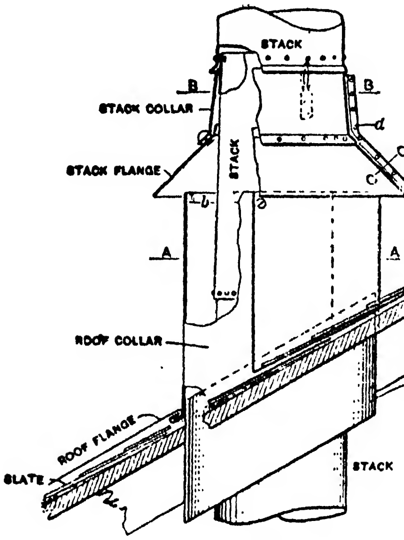


Fig. 128

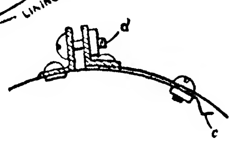


Fig. 133

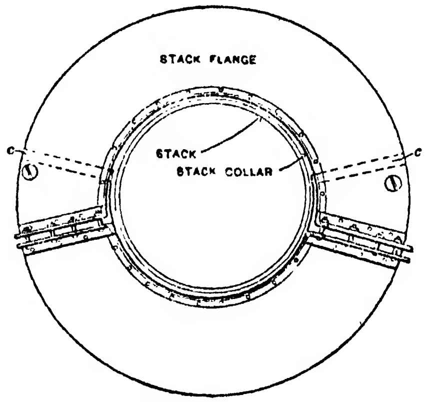


Fig. 130

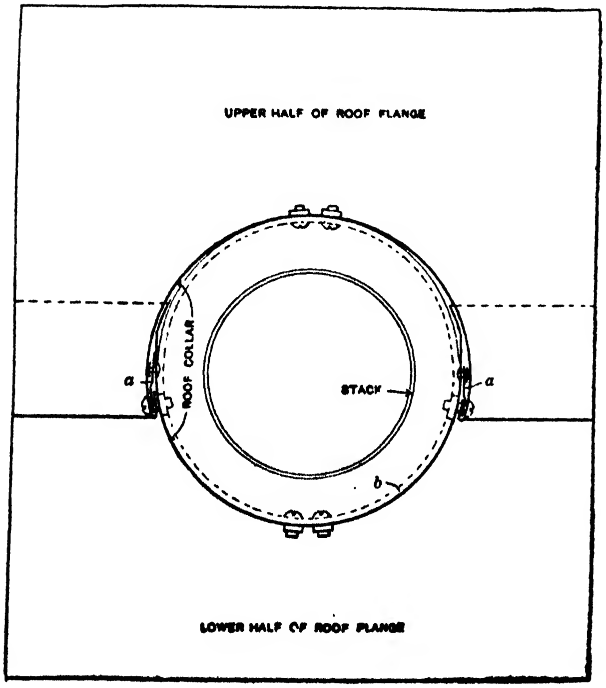


Fig. 129

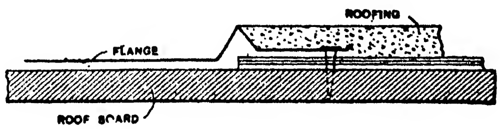


Fig. 131

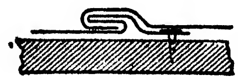


Fig. 132

CONSTRUCTING THE CONNECTION BETWEEN A SMOKE STACK AND A ROOF

Fig. 128 shows a sectional side view of a very good form of connection. Fig. 129 is a section on A A, Fig. 130, a section on B B and Fig. 133 a section on

C C. Fig. 128 shows a stack piercing a slate covered roof, in which case the roof flange can finish with simple raw edges, as indicated in Fig. 129. This also holds good in the case of a shingle or tile roof, except that in the latter case the flange should be fluted to conform to the profile of the tiles. If the roof is covered with tar and gravel the edges of the roof flange should be finished with a gravel stop, as indicated in Fig. 131. If the roof is covered with tin the flange should be provided with simple lock edges and be joined to the roofing as indicated by Fig. 132 and the seam soldered.

The roof collar should be double seamed and soldered to the roof flange, as indicated at the broken section, Fig. 128. The roof collar and flange is made in halves to allow placing it around the stack, and when the roof is covered with slate, shingle or tile, and consequently has considerable pitch, the two sections of the collar and flange can be joined as indicated in Fig. 129, cleats *a a* being riveted to the lower half of the collar and the upper half locked around same as shown. Ample lap should be allowed between the upper and lower halves of the roof flange and collar. The slate, shingle or tile work should be finished up as far as the lower half of the flange will extend and the latter then placed in position over the roof covering, The upper half of the flange is then put in position and the roofing laid thereon. If the roof is flat cleats *a a* should be omitted and the joint in the roof collar well riveted and soldered, the lap joint of the roof flange also being well soldered. The roof collar should project at least 12 inches above the roof at its upper side, and when the stack is large the upper edge of the collar should be stiffened with an iron band *b*, made in two parts and bolted in place after the collar is in place.

The stack flange and stack collar should be joined as indicated in the broken sectional view of Fig. 128, and also made in halves and connected as shown in Fig. 133. The small gutter crimp *c* takes care of any water that may drive in between the laps. The length of the stack collar is entirely dependent on the location of the most available joint in the smoke stack. This joint should be opened up with a cold chisel, so that the upper end of the stack collar can be inserted under same. The stack collar and flange can be drawn tight around the stack by bolts *d*, so that it will not be likely to slip down; but for large stacks a few lugs (one of which is indicated in dotted lines) should be riveted to the collar and secured by wires to the joint in the stack. Holes can be made in the outer thickness of this joint by driving a punch up underneath same and then using a cape chisel on the outside.

In the case of wood roof construction a lining collar for protecting the wood should be inserted through the roof boards into the roof collar and project downward

below the bottom edge of the rafters. This completely shields all wood work around the stack. In no case should any wood work be allowed within 4 inches of the stack, and when the roof is low and near the boiler there should be at least 6 inches of clear space all around the stack.

The gauge of metal to be used is dependent upon the size of stack, temperature, etc., but generally the roof collar and flange should be of No. 20 gauge galvanized iron and the stack collar and flange of No. 18 gauge. For small stacks, where the collar is located at a considerable hight above the boiler, lighter material can be used.

ROOF FLANGES FOR SOIL OR VENT PIPES

The base sheet should be large enough to give ample flashing all around and should be designed to suit the roofing material. On first-class work the flange should be of copper, but occasionally for some patterns of tile used for roofing lead will be found easier to work, as it can be formed into the depressions in the tile better than any other material and will lay closer.

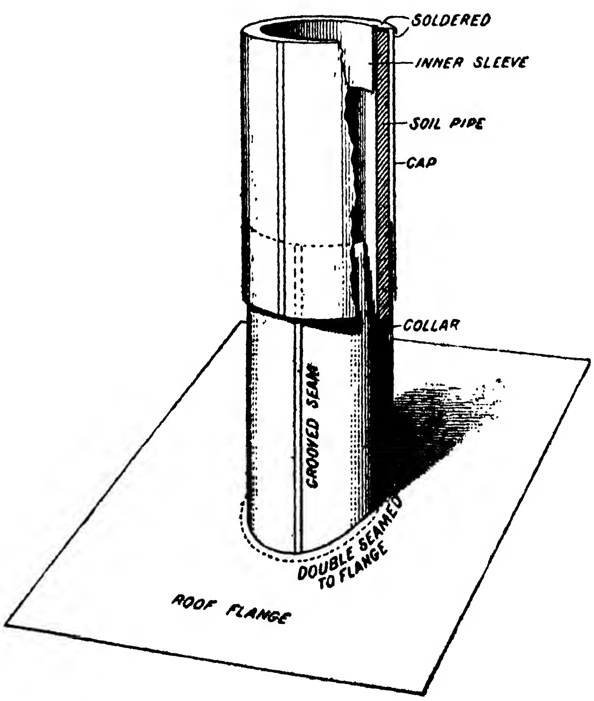


Fig. 134. Roof Flange for Short Stacks

The size should be ample but vary to suit the roofing material. A metal roof, affording a surface to solder the base plate to, will require a smaller flange than any other roofing material. A slate, a shingle or a paper roof will require a larger flange and a tile roof will require a still larger. In every instance the roofer should be consulted if possible, and on new work, if he is on the job and will make a reasonable price for the work, he should be engaged to do it, as his contract generally requires him to guarantee all roofing for a fixed period of time, and unless he does this work he cannot under his guarantee be made responsible for it.

The collar should be double seamed into the base flange, and the seam heavily soldered on the outside. The vertical

seam of the collar should be on the lower side of the pipe, so the water from the roofing above the pipe will not run against the seam. The collar should be enough larger than the pipe to allow same to slide through easily. In making it the collar should be about ¼ in. larger in diameter, or ⅞ in. larger in circumferenc, than the outside of the pipe of which it is to go outside, for it will be found that if this allowance is not made the double seaming of the collar to the flange loses some of the clear opening and will cause the collar to bind if it is not made large. There should be no binding whatever and the collar should drop over the pipe and slide down into place of its own eight. Absolute freedom is necessary because the expansion and contraction of the pipe is always causing it to move up and down, and if the pipe is long this movement is considerable. The settling of the building, or of the rafters, or the shrinkage of the roof timbers and floor joists often cause an inch or more of a variation. In either contingency a flange fitting the pipe tightly is almost sure to cause trouble by buckling and cracking, breaking the seam where the collar joins the flange or by breaking the roofing material.

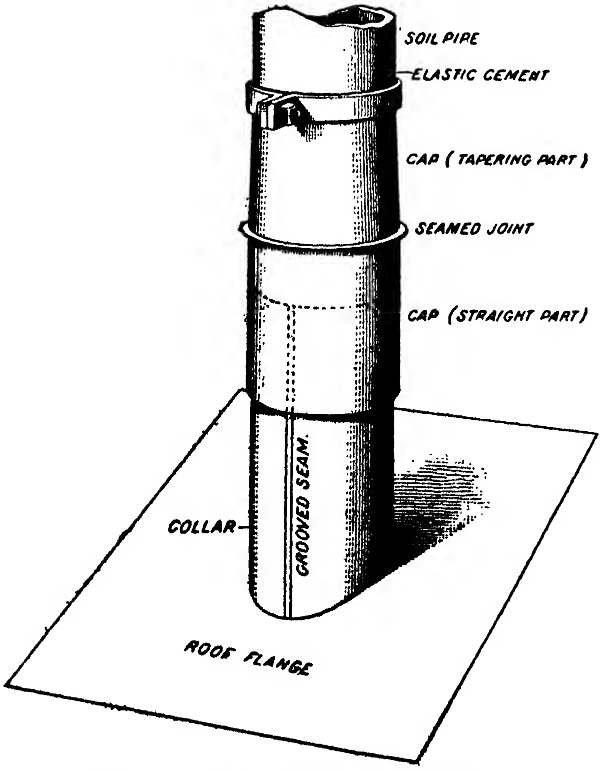


Fig. 135. Roof Flange for Tall Stacks

The collar should be at least 12 in. high, and 18 in. would be better, Fig. 134. The above method provides a practical and not very expensive way of making a tight connection at the roof, and the connection to keep the water from getting down into the building between the collar and the pipe is simple, especially if it is not necessary to run the pipe more than 2 or 3 ft. above the roof.

A cap should be made ½ or ¾ in. larger in circumference than the collar and long enough to reach from a point 6 in. lower than the top of the collar to the top of the pipe. This is nothing more or less than a piece of round metal leader with a grooved seam. Then a sleeve 2 or 3 in. long should be formed of sheet metal into a cylinder just a little larger than the inside of the pipe which passes through the roof. This should be put into the pipe and opened up

as much as possible until it fits snugly and is tight inside the pipe, and then the seam should be soldered.

A circle should be cut of metal large enough to have a burr turned all around the outside edge and then leave it the proper size to snap onto the cap and be soldered. Then cut a hole in this circle just slightly larger than the inside diameter of the soil pipe. Turn a ⅛-in. edge out square all around on one end of the little sleeve made to fit into the soil pipe, drop it through the hole in the circle and solder it. Then the cap dropping down over the soil pipe is held snugly in place by the inner sleeve and the lower end laps down over the collar, forming a cap flashing that is water tight but which will allow free play to the pipe and the collar.

Of course, if the pipe must extend too far above the roof to make the above cap impracticable, some other arrangement must be made. The best would be to make the lower 8 in. of the cap the same as described above and then to double seam to this a tapering piece about 5 or 6 in. long with only enough taper to make it just the size of the outside of the pipe at a point 1 in. below the top of this tapering piece, Fig. 135. Then run it through the thick edge and form a slight depression clear around it and 1⅛ in. below the top edge.

From this depression to the top edge stretch the metal gently on the conductor stake or on a piece of pipe with a hammer until it is parallel with the lower straight piece of the cap. It should fit the pipe snugly.

If it cannot be soldered to the pipe a metal band of 3-16×1 in. galvanized steel should be made to go around the top flange of the cap, formed to fit snugly with both ends turned out square and so that they will have a space of ¼ in. (or ½ in. if the pipe is very large) between them. There should be a hole in each to take a bolt used in drawing the band tight to the pipe. To place the cap, drop it down over the pipe and over the collar of the flange to the proper position.

It should not have the top edge of the straight piece at the bottom of the cap closer than 1 in. to the top of the collar of the flange and 2 in. would be safer. Force elastic cement down between the flange of the cap and the pipe, put on the band, screw it up tight and then put elastic cement over the top and against the pipe and smooth it off with the cement beveled away from the pipe.

This connection allows absolute freedom of the pipe within the collar and of the collar within the cap, and is a perfect method except for the joint where the top flange of the cap hugs the pipe, but if this is properly and carefully made it should never give any trouble.

If the vent pipe does not extend very far above the roof and lead is required,

this flange is made by forming a pipe of sheet lead slightly larger than vent pipe and with one end trimmed to suit pitch of roof and long enough to dress into vent pipe as shown by Fig. 136. This sleeve is soldered to a suitable base sheet.

A good method for screw pipe vents is to have a coupling reamed which covers the sleeve. Fig. 137 illustrates this method. This coupling is screwed on after flange has been set. It is best to make this flange of stiff metal—say cold rolled copper. A popular manner of making the roof tight around vent pipes is

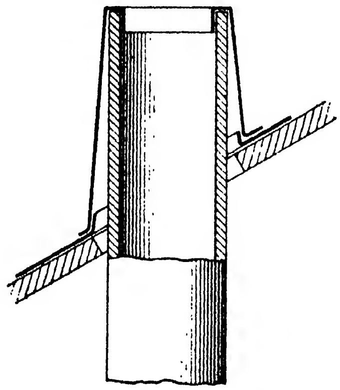


Fig. 136. Lead Sleeve Turned into Vent Pipe

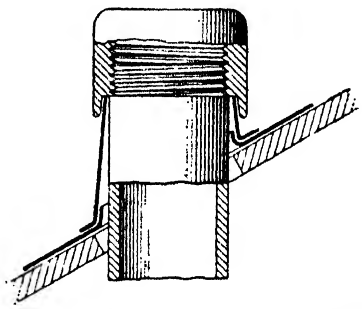


Fig. 137. Sleeve Fitted Under Recessed Coupling of Vent Pipe

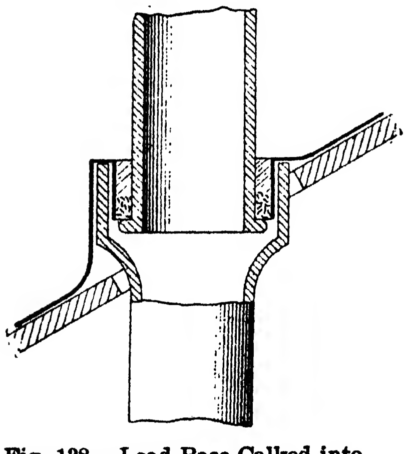


Fig. 138. Lead Base Calked into Vent Pipe Joint

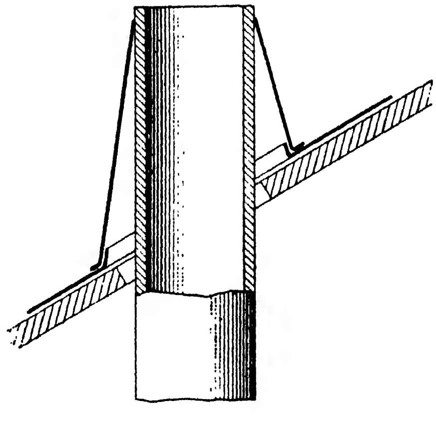


Fig. 139. Sleeve Fitted Snug Around Vent Pipe

shown by Fig. 138. The top of the hub of the soil pipe is almost flush with the roof and before calking the upper joint of vent pipe in this a sheet of lead with a hole cut out considerably smaller than the hub is dressed in the hub.

The usual way for roofers to make these flanges is as illustrated in Fig. 139. Though this is not recommended it is used more than any other method. A hole is cut in a piece of metal, for the base, somewhat larger than vent pipe, and the

shape of the hole is guessed at. If impossible to drop this base piece over the top of pipe it is slit in the front. Previous to doing this an edge is hammered up, on the coping stone generally as shown. A tapering piece of sheet metal pipe is fitted around this flange and pipe and a mark made on the seam. It is taken from pipe seam tacked with solder on the mark and an edge hammered out as shown. Then this collar is placed around the pipe again and while held tightly against pipe seam it soldered, also collar soldered to base, and to vent pipe. If it cannot be soldered to vent pipe it is paintskinned.

TINNING EDGES OF COPPER SHEETS FOR ROOFING

When laying a flat seam copper roof of either soft or cold rolled copper it is necessary to have the edges tinned about 1½ inches around the entire sheet on both sides, so that when soldering the sheets the solder will be thoroughly "sweated" into the seam. While this can be done at the mill, or with the soldering coppers, a much cheaper and thoroughly practical method will be shown

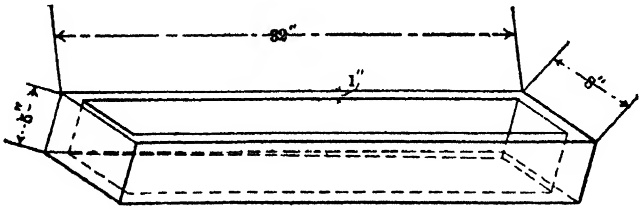


Fig. 140. Tinning Edges of Copper Sheets for Roofing—Copper Lined Box for Acid Bath

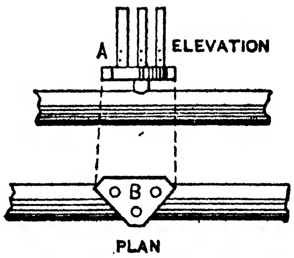


Fig. 143. Plan and Elevation of Burner Enlarged

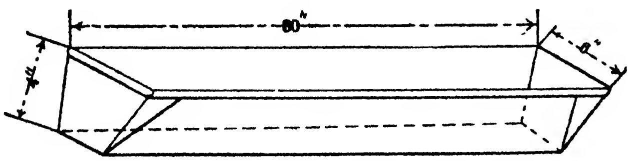


Fig. 141. Heavy Metal Pan for Tin Bath

herewith by which the sheets can be tinned to any required width, of any size, by any bright boy. When ordering sheet copper for this purpose a mistake is often made by taking large sheets and cutting them to the required size. This adds time and labor to the job which is not necessary, because the sheets can be ordered direct from the mill of the size and number required.

Assuming that this has been done, the first step required before tinning the edges is to notch the corners off the sheets, the same as in tin roofing. The scrap

from the copper sheets will then bring full price when sold for copper scrap, while if the sheets are tinned first the scrap is covered with tin and brings less money and uses more tin. When the sheets are all notched they are ready for the tinning, which is accomplished as follows:

First construct a wooden box of 1-inch stuff, of the dimensions shown in Fig. 140, or large enough to admit the size sheet in use. This box is then lined out with cold rolled copper, flanging and nailing along the top edge of the box. If the sheets are to be tinned around the edges to a distance of 1½ inches, fill the box with muriatic acid to a hight of 1½ inches, into which place zinc clippings, which will start the acid "boiling," the proper quantity of zinc being known when the acid stops "boiling." Care should be taken, in putting the zinc in the acid, not to add too much at a time, otherwise the "boiling," will be so violent that the acid will run

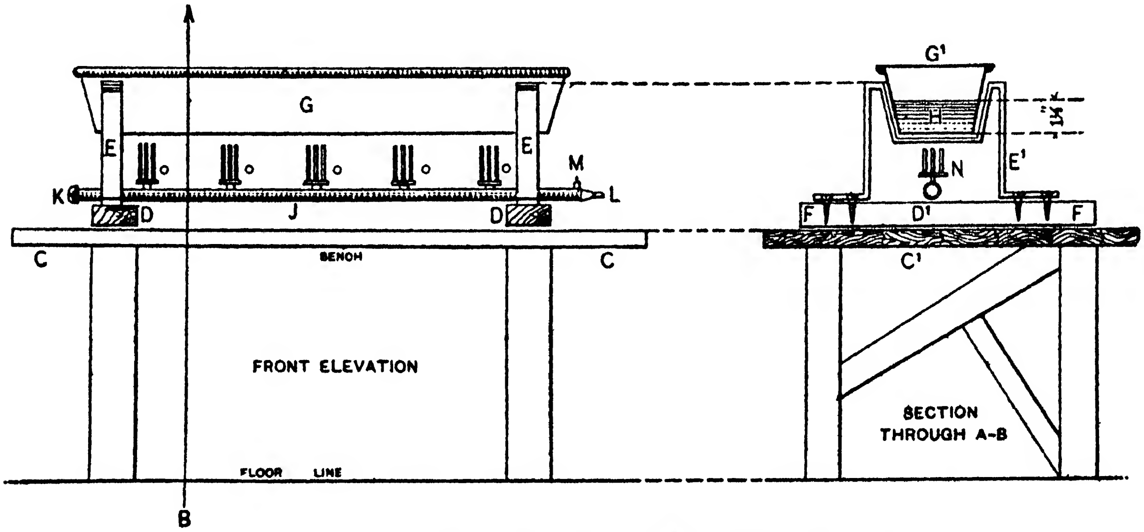


Fig. 142. Front and Sectional Views of Tin Bath in Position

over and be lost. Only small quantities of zinc should be put in the acid at a time, and when consumed more should be placed in until the acid stops "boiling." This is known as the "acid bath."

For the tin bath construct a heavy sheet metal pan, say of No. 16 black sheet iron, with wire edges, the corners constructed the same as in a drip pan, with additional rivets in the laps, and of the size shown in Fig. 141, or large enough to admit the sheet in use. This pan should be made tapering, so that when the tin becomes cold the pan can be tipped and contents removed. A general view showing the use of this pan is shown in Fig. 142, in which are also shown the arrangements by which the tin is melted by gas. If desired pure tin need not be employed, but a mixture of 50 per cent. tin and 50 per cent. lead can be used. The

arrangement of the gas and pan support is as follows: Let C C in elevation be the bench or any other support, shown in section by C^1, and D D in elevation two pieces of joist as long as shown by D′ in section, upon which the two iron brackets E E in elevation are fastened, as shown by F F in section. These brackets are made from $\frac{1}{4} \times 1\frac{1}{4}$ inch band iron, bent so as to receive the pan, and of sufficient hight, as shown by E^1 in section, to allow the burners to go under. The pan G in elevation, or G^1 in section, is placed into the brackets, as shown, the wire edges keeping the pan rigid at the top. The pan G^1 should be always filled with molten tin to a hight of $1\frac{1}{2}$ inches, as shown by H, always placing in a bar of tin or mixture of one-half tin and one-half lead, so as to keep the required $1\frac{1}{2}$ inches of metal in the pan.

For the gas connection obtain from a gas fitter a piece of gas pipe of the required length, as shown at J in elevation, with a stop-plug at K and a gas hose fitting at L, or a stationary connection can be made with a stop-cock at M. Holes are then tapped into the gas pipe and air burners having three tubes each are placed about 7 inches apart, as shown by O, O, O, etc., and as shown in section by N. In Fig. 143 is shown an enlarged view of the burner, showing the air holes in the three tubes at A in elevation, while B shows the plan view of the tubes. It is possible, though, to buy Bunsen burners complete.

When tinning the sheets the acid and tin baths are placed in convenient positions and the copper sheets placed in a position between them. Then two adjacent edges only, of a sheet are immersed in the acid bath; holding the sheet with a pair of tongs or protecting the hands with a heavy pair of gloves. Holding the sheet a few seconds with the corner in a vertical position to allow the acid to drip off, immerse it in the tin bath, leaving it in the bath a few seconds that the portion which is to be tinned will have the same temperature as the molten tin; then tip it slightly to allow the tin to run off toward the corners, and tin the other edge in the same manner. The sheets are now laid on one pile, which allows them to cool, when the other two edges are tinned. In this manner a boy can easily tin 300 sheets of 16×20 inch copper in a day. Care must be taken that the tin bath has the right temperature, otherwise the dripping becomes cold on the edges of the sheet and cannot be inserted into the roofing edger when edging. In case some sheets have become dirty or stained and will not tin, immerse them in raw muriatic acid first, then into boiled, then tin. When the sheets have all been tinned they are edged or folded in the usual manner, and laid on the roof by means of cleats, so as to allow for the expansion and contraction of the metal.

REMARKS ON COPPER ROOFING

Copper is a material which nearly always gives satisfaction as a roofing material when it is properly applied, and complaint is rarely made except where it is traceable to poor or careless workmanship. A few points to observe in using this material are to take the utmost pains to provide for the expansion and contraction of the metal, which has a greater latitude of expansion and contraction than any other roofing material.

For this reason it is desirable wherever possible to have the roof put on with the regular standing double seam, such as is used for tin roofing, using the wide gauge tongs and seamers, or else have the roof put on with the sides of the sheets turned up against wood ribs which are run up and down the roof and which are then covered with strips of copper locked over the sheets on each side of the wood rib and these seams malleted down against the ribs. Of course the sheets are cleated to the ribs, and the finished rib, in section, then looks like the accompanying sketch, Fig. 144. A like finish is made against the hips and ridges.

All cross seams should be heavily tinned before the copper is put together in rolls, preferably by dipping the end of the sheet into cut acid ½ in., and then dipping into melted solder about 2 in., leaving in for 5 or 10 sec. and then removing. A slight shake should be given the end of the sheet to shake off just a little of the surplus solder, but the remainder of the solder should be left on the sheet. When this is done a good seam can be made, because when the seam is locked together and closed down tight, preferably on a cross lock seamer, the solder left on the ends of the sheets by this tinning operation is remelted when the seam is soldered and makes it practically solid all the way through, whereas if the extra solder had been brushed off or wiped off immediately after the tinning operation there would not be enough left on the sheets to help make the joint solid, and it would have no strength except that given it by what solder could be soaked into the seam by the iron.

The upper sketch in Fig. 145 shows a seam made by the former method. The seam is shown solid, with nothing to indicate which is the copper and which the solder except the difference in the color. The lower sketch shows a typical seam made where the solder soaked in by the iron is depended on. In the upper, with a ½ in. lock, the solder has a bearing surface of 3 in., while in the lower, with the same size lock, there is a bearing surface of only 1 in., and that only at the point where it is the hardest to resist the strain.

If it is impossible on account of the roof not having sufficient pitch to use the wood rib or the standing seam construction, a flat lock roof is necessitated and good results can be obtained, but the sheets should be tinned along all edges by dipping and leaving the solder on the sheets. The tin can be tinned on the ends of the sheets, put up in rolls, and then have the edges tinned by dipping the rolls (rolled loosely) in acid and then in the melted solder, leaving them in for 10 or 15 min. so the edges will get hot enough to let the solder flow off the edges and not stick them together. The roll should be shaken up and down to remove the surplus solder and then quickly unrolled on a bench or the floor, or the edges will stick when the solder gets cold. This method will be found much quicker than tinning with a soldering iron.

To facilitate the handling of the rolls a wire should be slipped through the hole in the center of the roll with a piece of rod or gas pipe through a loop at the bottom end and with a loop at the top end, through which a piece of gas pipe or a wood handle 6 or 8 ft. long can be slipped. A man and a helper pass the small piece of pipe through the hole in the center of the roll, and after it is through turn

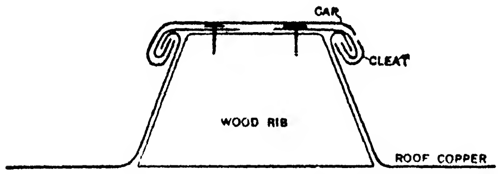


Fig. 144. Copper Roofing with Wooden Ribs

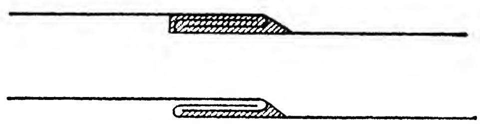


Fig. 145. Soldered Seams in Copper Roofing

it at right angles with the roll. They then slip the gas pipe or wood handle through the upper loop, raise the roll, dip it into the acid and then set it down into the hot solder, which is deep enough to come up on the roll 2 in. It is left in there about 10 min., while the men are putting in one or two more rolls, or taking out one or two others. They then remove it, giving it a few shakes over the solder to remove the surplus metal, and then they quickly unroll it, and after it is cooled it is rerolled and the operation repeated on the other edge.

In laying copper on the roof whether flat lock, standing seam or wood rib construction is used, the copper should be secured only by cleats, never under any circumstances using nails driven through the copper, though it is permissible to use a nail through the sheet at the top of a course on a steep roof to hold it in position until the cleating and seaming is completed. In this case the nail should not be driven down tight and should be pulled out and the hole soldered. The nail should not be driven down and soldered, as the sun will surely draw it up through the solder, no matter how heavily it is soldered.

If the roof is larger than 20 or 30 ft., either way expansion seams should be put in. A regular standing seam might be put in, turned down, heavily soldered, and then turned up again. Another point to observe is that when the roof is put on during hot weather more attention should be paid to providing for the expansion and contraction, especially to provide for the contraction, as that is what breaks the seams. Contraction will put considerably more strain on a roof laid in hot weather than on one put on in cold weather, because the expansion is at or near the maximum when the roof is laid, so that it is rigidly fastened at all edges the contraction will have its maximum effect. On the other hand, if the roof is laid during very cold weather but little attention need be given to providing for the contraction beyond seeing that no nails are driven through the sheets, as the contraction being already at or near the maximum, it is plain that it will put no strain on the sheets.

It is necessary to be careful that no buckles are formed in the sheets on the roofs or in the valleys or gutters, as these will, from the extreme contraction and expansion, soon cause the copper to break at the point of the buckle. The writer has seen this trouble experienced a number of times, and great care should be taken to avoid it. By tinning all seams heavily before sheets are put together, providing for expansion and contraction, putting in expansion seams where necessary, soldering all seams heavily with real half and half solder, and using cleats as the only method of fastening, there should be no trouble in securing a good piece of work.

Some may object that the method outlined herein are too expensive, but the writer can only say that copper being an expensive material no man is justified in failing to use any precaution to secure a satisfactory and durable job, especially when the extra cost of $1 or $2 a square forms such a small percentage of the total cost of the roofing. On a tin roof, costing $5 to $8 a square, the matter of $1 or $2 added to the cost would be serious, as it would be a handicap of from 20 to 40 per cent., but on a copper roof, costing $35 to $50 a square, it is a comparatively small handicap and one which is justified.

PRACTICAL TALKS ON ZINC ROOFING—I

A roofing which has special advantages for covering light structures, inasmuch as it can be laid on zinc without any boarding whatever beneath it, is what is known as the "Italian corrugation." It consists of sheets of the usual dimensions with one central semi-circular corrugation longitudinally, and a curved lap at each

side. This stiffens the sheet, so that in the case of large spans, the principals and framing may be lighter than usual, and, as a consequence, less in cost. The purlins may be as much as 10 ft. apart, if desired. The patent embossed hole and screw is very handy for fixing this style of corrugation; in fact, the work in connection with it is very little. Referring to the engravings, it may be stated that in Fig. 146 is given a longitudinal elevation of a portion of the wooden roll A, with the corrugation B, and laps C, which should be about 4 in.; D being the bossed

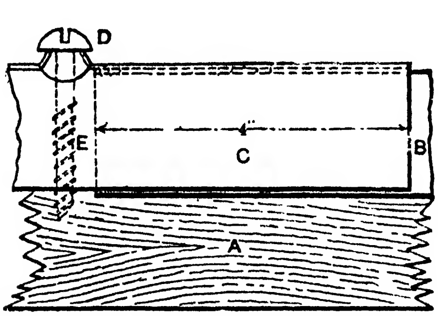


Fig. 146. Longitudinal Elevation of Wooden Roll

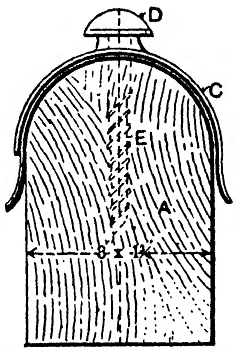


Fig. 147. Section Through Roll and Cap

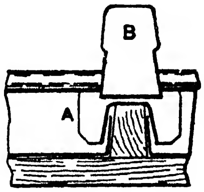


Fig 148. Elevation Drip for Common Roll Cap

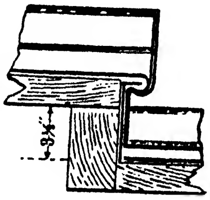
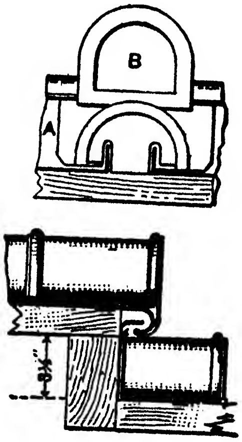
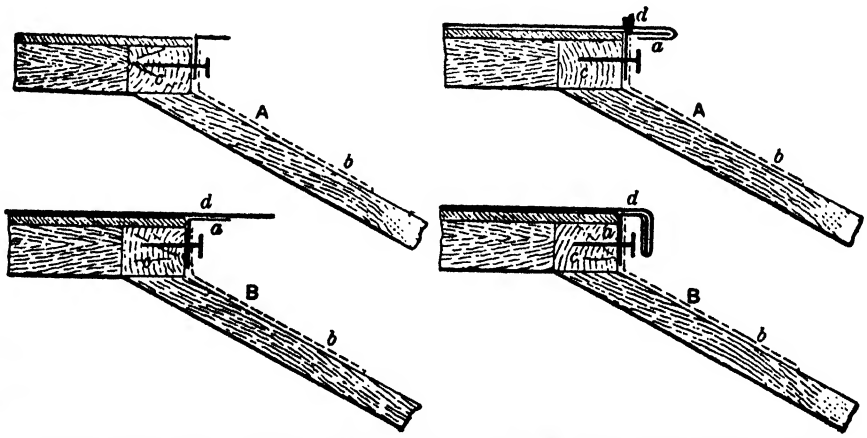


Fig. 149. Section of Drip for Common Roll Cap



Figs. 150 and 151. Drip for Patent Roll Cap



Figs. 152 and 153. Method of Treating the Edges of the Zinc in Covering Flats or Platforms

hole, and E the screw. Fig. 147 is a section through the roll and cap, showing the extent of laps. The screw should never be permitted to penetrate both sheets.

The wood rolls or battens may be $1\frac{3}{4} \times 3'$ in. Where drips are necessary in zinc covered roofs they are arranged similarly to those on which lead is laid. Those for the style of common rollcap, which has been spoken of, are shown in elevation at Fig. 148, and in cross section at Fig. 149, A representing the extremity of the lowermost cap in each case, and B the stop end of the upper roll. A fall of 3 in.

from bottom to bottom is usually sufficient. The drips for the patent roll caps are given at Figs. 150 and 151, the reference letters being the same as in Figs. 148 and 149. In consequence of the upturn of the lowermost roll, a fall of 3½ in. must be given to the boarding of the roof.

The application of zinc for the purpose of covering flats or platforms of pavilions or temporary structures is also useful. In roofing, the carpenter will of course give the platform the slight necessary fall, and fix in its center, between two slopes, a stout batten of about 3 in. square, to do a somewhat analagous duty to the ridge pole of an ordinary roof, unless the roof is of very small extent. Of course, where, on the contrary, the surfaces are very large, the carpenter wili have to make provision for drips. That being arranged, the first thing is to secure the edges of the platform by nailing (preferably with end-headed nails) a strip of zinc or lead 4 in. wide along each edge. The sheets of zinc must also have an upstand at each side against the wall as far as the roof, and a similar set-up of 3 in. at their top ends, which butt on the central ridge or batten. The upstand of these ends should be soldered to that of the sides at each corner.

The edges of the zinc at the boundaries of the platform have now to be turned over the projecting strip of zinc or lead, as shown in Fig. 152. In the sketches the strip or clip of lead or zinc is indicated by a dotted line. Of course the zinc of the flat is cut level with the strip before turning in. The set-up against the roll should be slit at the level of the roof, so that it projects on each side of the roll, and a small piece of zinc, of size sufficient to project as much, say 1½ in. beyond edge of pavilion top, should be soldered over the same. The roll being then slipped on the wooden rolls, and clasping the two upstands of the zinc sheets, a small piece of the zinc roll, sufficient to cover the projecting pieces soldered on should be mitered and soldered to the end of the roll, thus completing it and carrying it over the edge of the platform, as shown by B in Figs. 152 and 153. The end of the zinc roll, which butts on the central batten, should also have a small piece of zinc soldered to it, in the same way that the roll terminating at a ridge pole has. The central ridge, or batten, may be made in two pieces as described for the wood rolls, only larger, say 5 in. or $6 \times 1\frac{1}{2}$ in. or 1¾ in. This is best covered with lead, well dressed down over the top upstand of the zinc sheets, and the zinc soldered to the ends of the rolls.

Of course, any of the other forms of roll cap, etc., which can be used for roofs are also capable of employment for flats, and equally of course, the distance of the wood rolls apart will vary according to circumstances and to taste. Thus the zinc may be either used of its full breadth, or cut down the middle and applied in hal

sheets. So, too, the rolls may differ in size, and of necessity the zinc roll caps with them, according to locality of roofs, etc. Where bold effect is desired, the large size will be used, and they are more impervious to wet where the fall is slight, or exposure to wind or snow likely to be great.

It is essential in external zinc working, as in that of lead, to leave the metal, so far as possible, free, and with plenty of play. Separate sheets should on no account be soldered together, although, of course, (as it is not possible the lengths of the sheets as obtained should fit every roof) occasionally a sheet must be lengthened by soldering a piece to it. Zinc for flats and platforms of pavilions should always be of tolerable substance. Zinc pavilion roofs are frequently, at the present time, enriched to a great extent by oval and variously formed louvres, window openings finials, etc.; and even in some cases the metal is used in imbricated plates similar to fancy roofing tiles. This is an old fashion revived, for similar forms were given to lead in the seventeenth and eighteenth centuries, especially in France.

Zinc is of course not inflammable. It is therefore a safe covering for any building, including the private residence. There is a current belief among architects that zinc will burn. It is true, that a very high temperature sufficient to make iron red hot or crack slate would cause zinc to vaporize giving the appearance of burning by throwing off a bright green flame, but no ordinary temperature will do this.

PRACTICAL TALKS ON ZINC ROOFING—II

There are several reasons why zinc has not been generally used in this country for roofing purposes: It is more expensive than roofing tin. It requires more careful handling. It expands and contracts more than any other metal used in roofing, so that if unskillfully laid it will not give satisfactory service. It will not give long service near the sea, or in the vicinity of chemical or iron works where fumes from the processes of manufacture are discharged into the air, the condensation and precipitation of their components corroding the zinc very rapidly. A large roof in Newcastle-on-Tyne, England, covered with 22-oz. zinc was corroded so badly in 18 months that it had to be stripped and re-covered with sheet lead, but this case is exceptional.

Given proper conditions and careful workmanship the metal will undoubtedly give long service. There are hundreds of roofs "on the other side" which are perfectly sound after 30 and 40 years' service, and there is no reason why it should not do as well here. The important thing to bear in mind in laying it is its high

co-efficiency of expansion. In a climate where the variation in temperature may be 120 degrees there must be ample room left for the sheets to expand without "bulging" and cracking, and to contract without pulling away clips, fastenings and soldered seams. This is easily accomplished, as the sketches will show.

In covering a roof with a fairly steep pitch the procedure is much as in using tin or galvanized sheets with standing lock. The lateral seams, however, are not soldered. The turnover at the top of the sheet is 2 inches, while the lower end of next sheet is turned in 1 inch only. This gives ample lap, and when put into place the seam is flattened by a soft wooden dresser. Zinc clips 2 inches wide, two

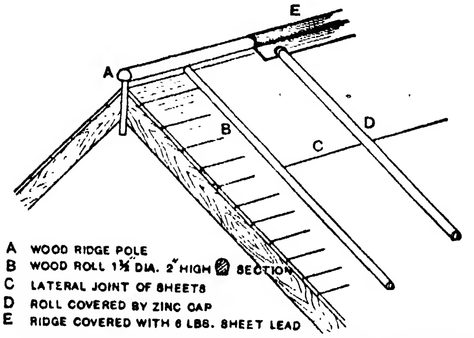


Fig. 154. General Scheme of Zinc Roofing Work

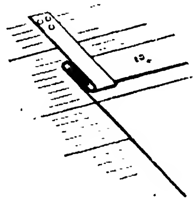


Fig. 155. The Use of Clips or Cleats

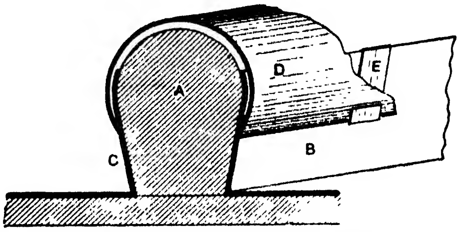


Fig. 156. Section of Roll and Cover

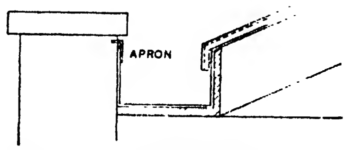


Fig. 157. Arrangement at Gutter

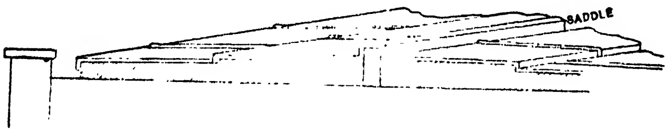


Fig. 158. Flat Roofs with Drips and Saddle

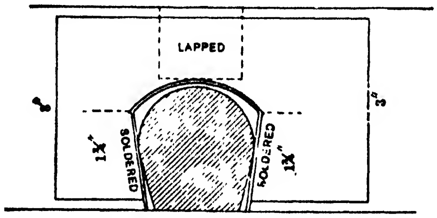


Fig. 159. Lapping of Upstands at Drip and Saddle

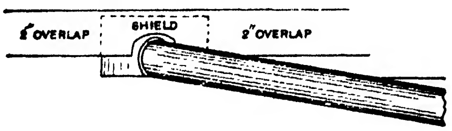


Fig. 160. Roll Cap Shield at Drip

to each sheet, are folded and nailed into place as in Fig. 155. These prevent the sheets slipping down the roof. The lower edge of the bottom sheet and the end sheets are prepared and fixed over an edging strip same with tin roofing, or set up against a coping or wall 3 inches or more should the roof require it.

The side next to the wood roll for the longitudinal seam is set up 1¾ inches as shown in Fig. 156. This is dressed a little beyond the square, as the roll is narrower at the bottom than at its upper part. Then the wooden roll is nailed down with strips of zinc 9 inches long about 1 inch wide fixed under it. These strips are bent over the upstand or the turned up edge of the zinc and then up on the edge

of the cap when fitted, where they are soldered, thus preventing the cap from slipping and dispensing with any necessity of nails through it. The top sheet next to the ridge should be set up $1\frac{1}{2}$ inches and the corners soldered. A clip may be soldered to the under side of the sheet and nailed to the ridge pole to support this sheet, or it may be nailed to the lower side of pole as the lead will give ample lap over the nails. When all the sheets have been laid, the zinc cap is slipped on from the lower side, taking care not to expand it so it will lose its close grip on the upstands. The clips are then trimmed off and soldered and the ridge covered with 5 or 6 pound lead, snugly dressed over the rolls and close in to the roof proper. The caps may be finished at the eaves with a blank end soldered in, or returned, if the roof delivers into a gutter as in Fig. 157.

Covering a flat roof or a roof with little pitch with zinc is rather more troublesome, as it has to be laid in steps. Commencing at the eaves in the usual way, or by dripping it into a gutter, the sheets are set up as before described for the edges and roll seam; but instead of making a flat or lock seam at the lateral junction, a drip must be formed—that is, where the length of roof requires more than one 8-foot sheet. The rise to the next flat should be 3 inches, and the first sheet is set up that hight at the upper end. At $1\frac{3}{4}$ inches up the upstand is notched and the lower part bent around the longitudinal upstand and soldered, while the upper part is allowed to lap over the top of the roll onto the next sheet, Fig. 159. When the roll cap is slipped on a shield about $2\frac{3}{4} \times 3$ inches is fitted to the end pushed close up to upstand and soldered to cap, as in Fig. 160. The next sheet being turned down 2 inches covers this, so that sufficient room is left for each sheet to move. The sheet should never be turned down over this drip more than 2 inches, or at most $2\frac{1}{2}$ inches, or trouble through capillary attraction may be experienced.

The caps are tied down in the same manner described. The saddle, if one is necessary, may be covered either with zinc or lead, making provision for clips below the apron part to prevent its blowing up, and making any necessary joints, if zinc with roll and cap or if lead, by working a hollow roll seam.

Zinc flashings, aprons, etc., are commonly used now, and all that can be said about them is that proper provision must be made likewise for expansion. Zinc is a hard metal to work in cold weather and should always be warmed before a sharp bend is attempted. It is well to lay the sheets out on a flat surface before using them. They can be much more easily handled if this is done. Zinc requires no painting. Where no other influence than the weather acts on it the oxidization tends to preserve it, but should there be any possibility of damage through sulphurous fumes, etc., a good coat of lead paint will protect it.

PRACTICAL TALKS ON ZINC ROOFING—III

The information here given was secured at first hand during a residence in Germany. Sheet zinc was first used for roofing purposes in Germany about the year 1800, and it has continued in popularity and has given entire satisfaction ever since. It is estimated that, at the present time, 35 per cent. of the total output of the German zinc mines is used for this purpose. A roof made of No. 16 gauge zinc is guaranteed to last from 30 to 40 years without repair. Thus its value is obvious.

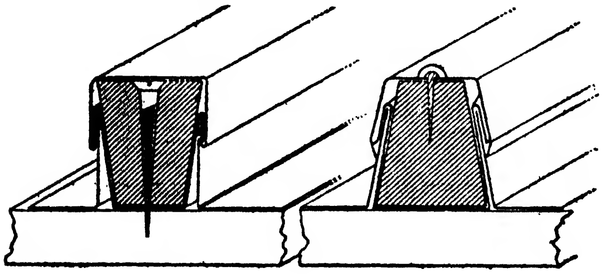


Fig. 161. Belgian System **Fig. 162.** French System

Zinc is a metal that expands and contracts through climatic changes to a greater extent than any other known metal. If proper allowance is not made for this expansion and contraction, when constructing a roof, the zinc will buckle and bend, and finally tear, and the older it gets the more brittle it becomes.

The chemical action of zinc, it is, well to note, is under ordinary circumstances, similar to the oxidation of iron. Under the action of air and water, an oxide of zinc covers the material, which, however, can easily be brushed off in the early stages. In a few weeks' time, however, this oxide will become so settled that it cannot be brushed off. Even water will not affect it. It is this oxide that protects the zinc from all ordinary influences. This oxide, however, will not, of course, withstand the action of acids, such as are emitted from chimneys, nor of the salt air from the ocean. Lime, as used in mortar, and cement in concrete also have their influence upon zinc, especially upon new zinc. This, of course, refers only to fresh mortar and concrete. The chemical action in this process, while very slow, lasting nearly two years, is a sure one.

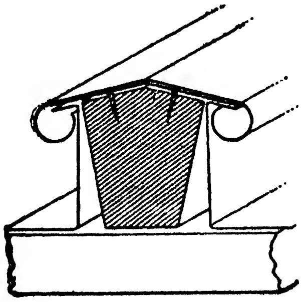


Fig. 163. German System

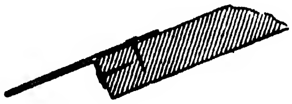


Fig. 164. Eave Strip

Soot that may lie on the zinc will form electric currents, if the same is wet through rain or moisture. These currents, no matter how weak, will act upon the oxide and seek the weakest spots in the sheets, so that holes will soon appear that have been eaten through the body of the zinc. The same result will happen if copper or iron comes in direct contact with the zinc. This is one reason why all

cleats used on zinc roofs must be tinned. All iron work, too, that comes in contact with zinc should be galvanized or tinned.

The different systems of zinc roofing are in use in Europe, known respectively as the Belgian, the French and the German systems. All have been in use a good many years, and they are, with a few minor variations, nearly identical in

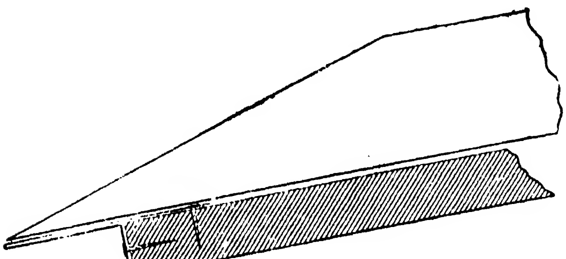


Fig. 165. End of Strip at Eave

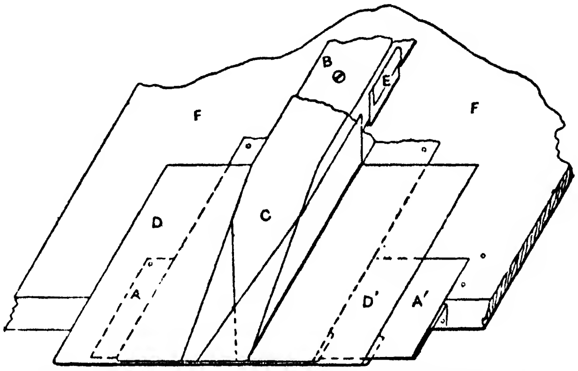


Fig. 166. Finish at Eaves—Showing Metal Cap

construction. Each kind has its own peculiar shape, but all strive for one point—allowance for expansion and contraction. In Fig. 161 is shown the Belgian system, which is the one we describe below. Figs. 162 and 163 represent, respectively, the French and German systems. In all three systems cleats are nailed to wood strips about 9 inches apart, before the strips are nailed to the roof.

As above stated, zinc is a metal that expands with the heat and contracts with

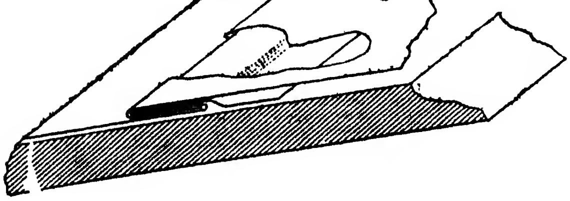


Fig. 167. Broken View of Cross Seam—Showing Cleat

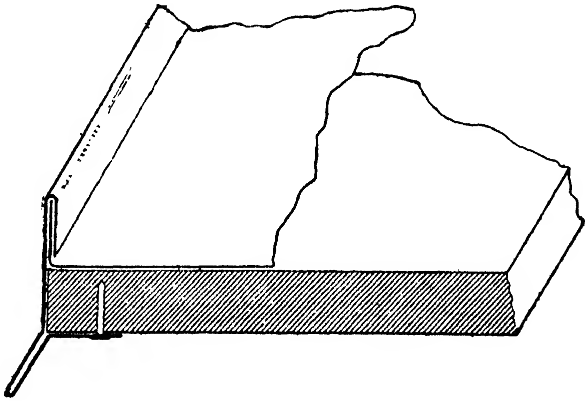


Fig. 168. Finish at Gable

the cold, and for this sufficient allowance must be made when the roof is being laid. A sheet of zinc 36 inches wide and 72 inches long will expand at least $\frac{1}{8}$ inch in width, and nearly $\frac{1}{4}$ inch in length in hot weather. Nails should never be driven into the sheet. Nothing but cleats should be used. If nails are driven

into the sheets, the heat will cause the zinc to buckle, and it will pull away from the nails, leaving a hole, which will cause a leak. This point, and that of expansion and contraction, must be carefully considered in laying a zinc roof. The action of the expansion and contraction is somewhat different on the Belgian system from that of the other systems. The zinc, in the Belgian system, moves into the bottom of the wood strips, whereas, in the French, it moves up the sides of the strips. In forming the edges of the sheets, care must be taken always to get them as round as possible. If this is not done, the zinc, in a few years, will crack at these points.

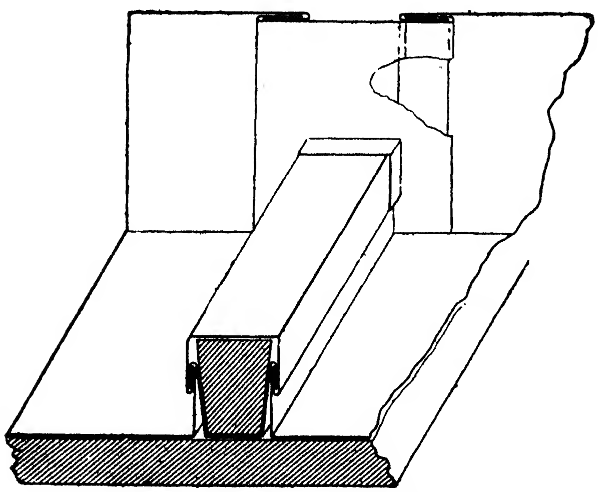


Fig. 169. Wood Strip Butting Against Wall

To lay the roof an eave strip of iron is formed as shown in Fig. 164. In using sheets of zinc that are 36 inches wide, the wood strips must be 34½ inches from center to center. Before the wood strips are nailed to the roof, the cleats, as shown in Figs. 161, 162 and 163, must be nailed to the bottom of the strip. The lower end of the wood strip is cut off as shown in Fig. 166.

The wood strip is then nailed to the roof, and over the end of the wood strip is placed a metal cap, formed as shown in Fig. 166. This cap is nailed to the roof

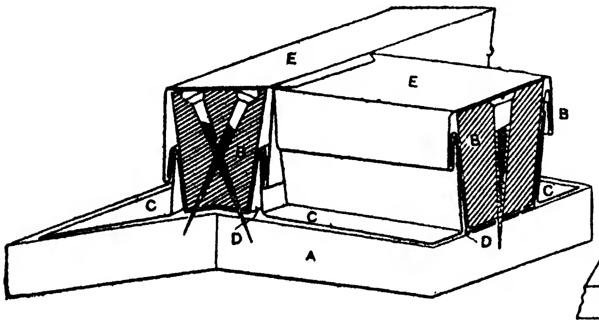


Fig. 170. Showing Ridge Strip and Common Strip

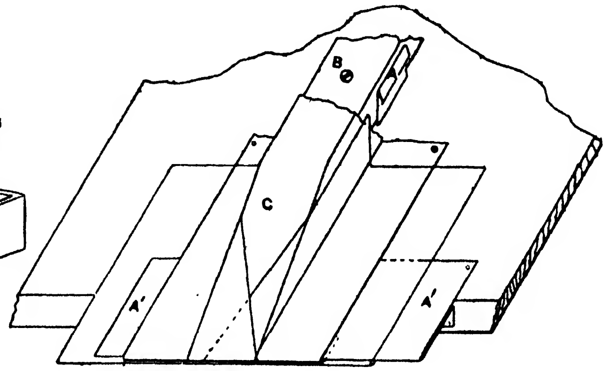


Fig. 171. Showing General Construction of Zinc Roof

and not to the wood strip. If there are any valleys in the roof, 12 inches should be allowed on each side of the same and the strips be cut to this line. The same should be done at the eaves. The same shaped cap as is used at the eaves should be used at the valleys, and should hook into the seam of the valley, which should

not be less than 1 inch wide. The wood strip at the ridges and hips can be made twice as large as the longitudinal strips. They can also be made of one size.

After the strips are all nailed to the roof, the same is ready to be covered with zinc. The cross seams are the first to be formed. These are formed as shown in Fig. 167, which gives a broken view of the cross seam, showing the cleat. After these seams are turned, the sides can be turned in this manner. Take a piece of leather or sheet lead and shove it in the cross seam, turning the sides up 1½ inches. Turning seams in this manner does away with soldering. After the sheet has been

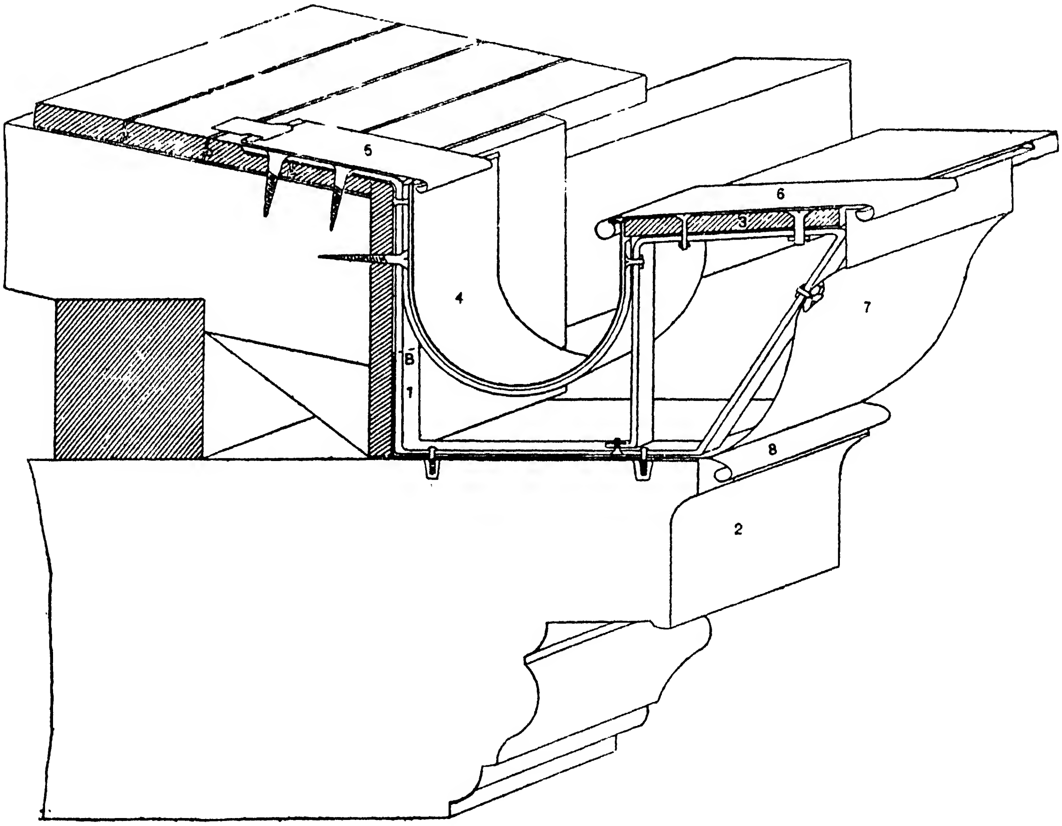


Fig. 172. Construction of Gutter

laid in its place, nail two cleats in the upper cross seam. As the sheets are laid in place, turn the cleats down over the sides. These cleats must all be of a uniform hight, so that when a cap is shoved over the ridge strip it will not be too loose.

The finish at the gable is indicated in Fig. 168. If there is a wall to be flashed that runs paralled with the wood strips, the same may be flashed in the usual manner. When a wood strip butts against a chimney or wall, however, flash as shown in Fig. 169. The sheets in this case are turned up from 4 to 6 inches against the wall, with the seams turned as shown, and the piece of zinc is shoved down

over the wood strip. The cap is then placed over the wood strip and soldered. Fig. 170 shows the method in which this work is carried out, with a ridge strip and a common strip.

When the entire roof is laid and ready for the zinc caps, the bottom of each wood strip is already cut off in the manner shown in Fig. 166. The zinc sheets are then turned over the wood strips, as shown in Fig. 171. From this, it will be seen that it is necessary for the zinc cap that goes over the wood strip to be formed on a slant at the lower end, so as to cover the entire strip. In Fig. 171 A and A′ are the eave strip, as shown in Fig. 164; B the wood strip, cut as shown in Fig. 165; C is the zinc cap; D and D′ zinc sheets, with the ends turned over the zinc eave cap; E the copper cleats and F F the roof boards.

Gutters, such as are used with zinc roofs, are of numerous shapes and styles. In Fig. 172 is shown the construction of a false bottom zinc gutter, which is one of a type generally used. In this sketch 1, is a band iron frame, 2 the sandstone cornice, 3 a running board, and 4 the gutter proper; 5 is the eave strip, 6 the cover for the running board, 7 a crown molding of zinc, and 8 a zinc strip that goes as far as B, to guard against condensation or leaks. There is not much need of going into details in describing these gutters, as the cut plainly shows the method of constructing them. If the gutter is very long, it is well to have expansion joints, so that the zinc can contract and expand at will. Fig. 173 shows the finished zinc roof, indicating the different sections.

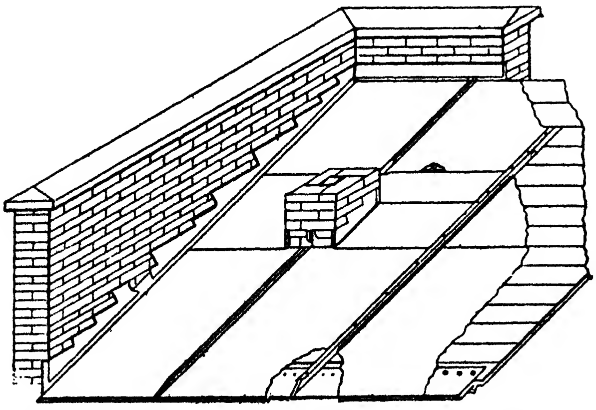


Fig. 173. Finished Roof—Showing Different Sections

In laying a zinc roof certain points should be kept in mind. In working zinc on cold days it is well to warm the metal to keep it from cracking. Cross seams are the only seams that are to be soldered, and then only when the roof has a pitch of less than 15 degrees. All cleats should be made of heavy copper and tinned thoroughly. Never drive nails into a sheet of zinc. Always see that there is room enough for the zinc to expand between the wood strips. Never use a sharp instrument in marking the zinc, as this is liable to cause cracks. When cross seams are not soldered, they should never be hammered flat. The cross seam on the lower sheet should be at least ¼ inch wider than the cross seam of the upper sheet.

Nos. 14 and 16 gauges of sheet zinc are generally preferred for roofing purposes, and nothing lighter than No. 12 gauge is ever used.

Where zinc is exposed to chemical action, as referred to at the beginning of this article, it can be painted, but, before any painting is done, the zinc must have a rough surface, such as is caused by the oxide or made by mechanical means. A good time to paint zinc—probably the best time—is when the roof has a thorough coating of oxide. The paint then takes a good hold and will remain for some time. Zinc can be painted at once if it is desired, but, as before stated, it must be on a rough surface. The rough surface can be gotten by either sandpapering the roof or scrubbing it with sand. The latter method is preferable, because it is the easiest. This will cause a roughened surface, to which paint will readily adhere. It is better, however, to wait until the roof has its own coating of oxide. The paint will crack and peel off if the zinc has not this rough surface. Silicate of zinc is the best mineral paint that can be used for this purpose.

LAYING TAR AND GRAVEL ROOFS

The sheathing can be laid with the pitch of the roof, or diagonally, or parallel with the eaves, for it makes absolutely no difference which way it is laid, so long as it is of even thickness and the joints are closed.

The roof will probably be a 3-ply, 4-ply, or 5-ply roof. In this connection, "ply" means "thickness," 3-ply means three thicknesses of the paper, 4-ply means four thicknesses, and so forth. The paper, or tar felt, comes in rolls. This paper is usually 3 feet wide, and a roll contains either 108, 216 or 324 square feet. This lays one, two or three squares of finished roof, 1-ply, or one square of 3-ply roof. This paper is generally sold by the ton, although it is sometimes sold by the roll. It weighs about 14 pounds per 100 square feet.

At the eave of the roof should be nailed a gravel guard of galvanized iron or copper, made as shown in the accompanying sketch, Fig. 174. Before it is put on, one course of paper should be rolled out parallel with the gutter, doubled over, and this double thickness laid on the sheathing, with the edge flush with the outer edge of the sheathing. The gravel guard is then put on, as shown, and the upper edge carried about 4 inches over the paper and nailed 3 or 4 inches apart. The outer edge is nailed also to the edge of the sheathing to hold it down.

The preparations, up to this point, are the same for a 3-ply, 4-ply or 5-ply roof, but differ somewhat from this point on. If a 3-ply roof is wanted, the roofer rolls out a strip parallel with the eave of the roof and stretches it along with the lower edge just touching the ¾-inch projection above the roof on the gravel guard. On top of this, 12 inches higher up, the roofer should roll out another course of paper, and then as many succeeding courses as may be required to cover the roof, each course covering 24 inches of the preceding one and leaving 12 inches showing to the weather. At the top end, sufficient is put on to insure that three thicknesses of paper is over all the sheathing boards. As each course is rolled out, it is nailed along the top edge with 1-inch barbed roofing nails, driven through flat tin caps, these nails and caps being about 12 inches apart.

In the meantime, the pitch has been heated in a kettle over the fire, and mops made of mop yarn tied to handles like broom handles. The pitch is drawn up onto the roof as needed in 5-gallon buckets. One man now starts along the edge of the roof and turns back the paper and holds it while another dips a mop in the hot pitch and runs it along on top of the gravel guard and the double course of paper under the same, the object being to give a liberal coat of tar, so that the metal will be firmly cemented to the paper under it, and there will still be enough pitch to thoroughly cement the first course of paper when it is released. If the courses are very long, the man holding the paper will soon get the knack of letting the paper fall over on the hot pitch, so that it will lie down smooth. Each succeeding course is turned back in the same way and the course next below it mopped for a distance of about 12 inches up under the course just turned back.

After this is done, the roof is usually covered with a thick coating of pitch poured out of a long handled dipper and deftly spread over the surface, care being taken to see that it is spread over every inch of the surface of the roof. Though some roofers spread the tar with the mop.

While this is being done, another man is busily pushing gravel, or slag, into the pitch just spread before it has a chance to cool. This gravel, or slag, should be dry, and if the weather is cool it should be heated, so that it will bed in the pitch before the same cools. If gravel is used, it should be screened and nothing used that will not pass through a ⅜-inch mesh, and nothing that will pass through a smaller than ¼-inch mesh. The whiter and cleaner the gravel, the cooler the roof will be and the better it will look. Gravel is generally used, but slag is sometimes substituted, although it is generally not considered so desirable by roofers, and is not so easily manipulated. The roof is now gone over with a broom and swept lightly, so that not too much loose gravel is left on it.

To flash around chimneys, walls, etc., copper is generally used. The roof should be laid and the flashing put down on top of the same, running up on the wall to the hight desired, and turning out on the roof 4 inches and nailed 3 inches apart. It is then thoroughly mopped over and a double thickness of paper laid over it. Especial care should be taken at these points particularly to see that the laps, etc., are all thoroughly cemented with the pitch. Many roofers put some dead oil in the tar used for flashing to keep tar from becoming brittle and thereby having a firmer hold on the metal; especially in cold weather. A 4-ply roof is laid the same as above, except that the paper laps 27 inches instead of 24 inches on each course next below, and each course shows nine inches instead of 12 inches to the weather. It can readily be seen that this insures four thicknesses of paper at every point on the roof, thus the term 4-ply.

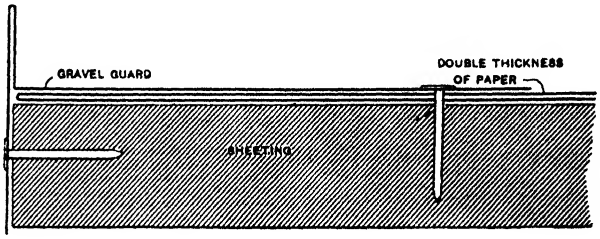


Fig. 174. Laying Tar and Gravel Roofs

A 5-ply roof can be laid the same way, showing 7 inches to the weather and lapping 29 inches, or it can be laid like a 3-ply roof, mopped over and then a 2-ply roof put on. This is the general practice and is the better method. When a 5-ply roof is laid in this way, the gravel guard is not put down until the 3-ply is laid and mopped over. This mopping over is done by spreading the hot pitch all over the surface of the roof with a mop, instead of pouring it on with a dipper, as explained above, when gravel is to be shoved into it.

The gravel guard is now put on on top of the 3-ply paper, and any flashing needed is put on and nailed and well mopped with hot tar. Then a course of paper is rolled out at the eave of the roof and 12 inches doubled under it, another course rolled out on top of it, 12 inches higher up the roof, and then succeeding courses are rolled out 18 inches higher up, each course lapping 18 inches over the one below and showing 18 inches to the weather. This is mopped along the edges, as described for the 3-ply roof, the pitch spread on and the gravel pushed in as described. When this is properly done by men who understand the business, a first-class roof is obtained at a minimum cost.

In this section of the country, thousands of acres of these roofs are put on annually. These roofs are often guaranteed for ten years. If a more durable roof is desired, asphalt should be used instead of the straight run American coal tar pitch, as it is more elastic and less likely to get brittle with age and cold weather. The use of asphalt adds about 50 cents per square to the cost of the job.

CANVAS ROOFING

Ten-ounce canvas is to be laid over a tongued and grooved floor which has been previously covered with a heavy waterproof paper. One object in using the paper is to provide a resilient cushion for the canvas, so that the impinging of the canvas against the edge of any obtruding board will not be cut or abraded by such edge or surface.

Wet the canvas before laying and paint the under side of the canvas while it is still wet with a heavy coat of white lead ground in linseed oil; lay the canvas while the paint is still wet; stretch the canvas as tight as possible, nailing closely with 4-ounce brass tacks; after being laid paint the upper face of the canvas with two coats of best white lead.

By proper care of the roof is meant the keeping of its upper surface covered with paint. In the course of a few years the paint oxidizes, scales off, irregular cracks and seams appear, and sometimes patches appear, which, if touched by the finger, crumble into dust. Whenever any of these defects appear it is time to go over the roof with another coat of paint, taking the precaution to remove all the old paint possible without injury to the canvas. Roofing canvas should always be mildew proof.

If a cement covering is to be used for a porch roof, first lay down a matting of wire mesh, or metal lath and fasten down firmly with galvanized iron staples, then apply a coating of Portland cement mortar in the proportion of 1 of cement to 3 of sharp, coarse sand. The sand is to be entirely free from loam or dirt of any sort, and the layer should be not less than 1 inch thick. A lesser thickness would be liable to crack under repeated strain of persons walking over its surface. The wire or metal lath furnishes a good bond and backing for the cement. Of the two, wire mesh is greatly superior to metal lath as to durability.

COLORING COPPER ROOFS GREEN

The best color is obtained by age, but for those who wish to obtain the effect quicker we reprint the following: The one method used most generally for turning copper green is a solution of sal ammoniac and water. Add about 1 pound of powdered sal ammoniac to 5 gallons of water, dissolve it thoroughly and let it stand

about 24 hours at least before putting it on the copper. Apply to the copper with a brush just as paint would be applied, being sure to cover every place. Let it stand for one day at least and sprinkle it with water, using a brush and splashing it on lightly, for if the water is put on too freely it will run the color and streak it. The next morning the color will be all that could be desired. The same effect will be produced by using vinegar and salt instead of sal ammoniac, using about ½ pound of salt to 2 gallons of vinegar.

THE BEST PAINT FOR GALVANIZED IRON

As to the paint for first coating galvanized iron, beware of white lead, because it remains soft and eventually peels; of zinc white, which will crack and flake; of any of the light carbon paints which require much oil to spread, because these will wrinkle and later on part. The cheap, ordinary mineral paints will not serve the purpose either, because these are most liable to peeling. Red lead, as a base for an all-oil paint, has given best service, but it, too, has given away at times, and the cause of the trouble appears to be that in an all oil paint the oil is attacked by the metallic zinc. A paint made from a heavy pigment that requires a small percentage of thinner for spreading will serve the purpose of first coating galvanized iron after, either leaving the surface to oxidize or by washing with dilute muriatic acid. Thus a mixture of equal parts by measure (not weight) of dry red lead and first-class mineral brown, ground together dry and then mixed by hand with equal parts of pure raw linseed oil and pure spirits of turpentine, without the use of any japan or liquid drier, has given the most durable and effective results. Over this priming any good oil paint may be applied and permanent adhesion may be looked for.

The reason for employing dry red lead is to let the paint oxidize on the surface rather than to have it saponify the oil in the pot, as there is ample proof that such paint is most liable to peel, it having lost its cementing qualities. Let it be noted, however, that this semi-flat, yet fairly elastic paint is to be used for first coat only and not as a finish. It is intended to isolate the oil paint from the metallic surface, to prevent the latter from acting on the oil. And under no consideration should boiled oil be used in mixing this first coat for galvanized iron. If a good grade of mineral brown cannot be had, a fine, chemically pure oxide of iron, such as Indian red, may be used in its place and serve the purpose even better. And no more of the paint should be made at any time than can be used the same day.

PAINTS FOR SHEET ZINC

A very durable weather resisting paint for zinc sheets is made by mixing oxide of zinc with a fluid silicate, such as water glass and potash of soda, to which the required pigments are added. The proportion should be about three-quarters of a pound zinc white to every pound of silicate, with or without water. This zinc-silicate paint becomes insoluble in water in about 24 hours. It is equally useful for interior and outside work, but it should not be applied to greasy surfaces, nor to old coats of paint. New zinc, not being oxidized, should first be prepared by the application of a solution of 1 part of soda in 10 parts of water, and then be washed thoroughly with water only.

To obtain a white color only pure zinc white should be used, but an excellent imitation of stone may be prepared by first mixing the proper coloring substance with water to the consistency of a thick paste, and then adding this to the mixture of silicate and oxide of zinc. The mixed paint can be kept in a closed vessel for 24 to 48 hours, provided it is put in a cool place.

Another quick drying, weather resisting paint of a dark color is made by mixing 6 pounds of graphite (plumbago) with 1 gallon of vinegar. The oxidized surface of the zinc, previously well brushed, is painted with the above, one coat giving a sufficiently dark color. New sheet zinc, however, requires two coats, and must first be oxidized by the following application, which is not strong enough to cause any deterioration of the metal: One part each of chloride of copper, nitrate of copper, and sal ammoniac, dissolved in 64 parts of water, and 1 part of hydrochloric acid added to the solution.

These paints should only be applied in warm weather, as they are best kept free from moisture for at least 24 hours.

PAINTS FOR ROOFS

A new hand who is sent out to paint a new tin roof is not apt to appreciate the importance of the work he has in hand, neither is he apt to be as fully equipped for the work as old hands who have been set to a similar task frequently. Whether it is a flat seam roof or a standing seam roof there are sure to be some places where soldering has been done. If the weather is good the older hand will immediately

hunt the soldered places and scrape off all the rosin that is along the seam or around the solder. If he is very careful he may have an old dust brush and a sheet of tin to take up this rosin and throw it over the eave, so that it can in no way become mixed with the paint to do any harm. After he has been careful with the scraping work, if the roof has laid a few days, he may have provided himself with a broom and will sweep all the dust off of the tin, so as to allow the paint to come in direct contact with the surface to be protected, with no foreign matter to interfere.

While the workman may have little to do with the character of the paint he is to apply he will have a great deal to do with the mixing of it and keeping it of the proper consistency while the work is being done. A great deal has been said about the kind of paint that is best adapted for painting tin roofs. Fortunately, for the avoidance of any monopoly, there are several kinds of paint which are very good. Venetian red and the metallic browns of the best grades are equally good. Unfortunately there are many metallic browns on the market and some have very little to recommend them, but whichever body is used, if it is ground in oil and mixed with good oil and then properly applied it will stand the ravages of time without a great deal of detriment. Many roofers may not be well qualified to discriminate in the selection of their paint, and under such circumstances they may safely rely on the paints which bring a cent or two more per pound before mixing as being better than those which sell at a lower figure and have little but the price to recommend them. The same may be said of oil. A good oil is rather expensive, but in experience the covering qualities are greater, and the difference in cost is not so great as the difference in the covering quality of the materials.

If it was possible to have good weather until the paint dried firmly the addition of some material to facilitate the drying would be neither necessary nor advantageous. Owing to the uncertainty of the weather, however, and from the fact that a small proportion of a good dryer is not detrimental, most men who provide paint for roofs will mix in a small proportion of something which will quicken the drying or hardening process. It is when improper materials are used in excessive quantities to the exclusion of good oil or form too great a proportion of the mixture that there is a positive objection to their use. When the workman has been furnished with the right kind of raw materials and appreciates the necessity of stirring the paint occasionally to prevent settling in the bottom and to keep the mixture of the same consistency he is ready for the tools to apply the paint.

If the roof is flat enough, so that he can walk around on it with safety, men differ as to whether a hand brush should be used or whether a broader brush may

be used on the end of a pole with good results. Some incline to the opinion that the brush on a pole cannot be made to do as good work in rubbing the paint in well and at the same time out so as to cover a large surface as when a hand brush is used. Certainly the workman with a wide brush on a pole can cover more ground with less labor and without tiring himself out as he would in the use of a hand brush. Old roofers who enjoy an excellent reputation for good work and the long service of the roofs do not require their men to use the hand brush, but are particular to see that the tool equipment is kept in good order. It is quite probable that some of the cheapest tin plates used by these experienced and careful men have rendered quite as good service as when high grade plates have been used by other men who have not appreciated the destructive effect of some kinds of painting material.

Some of the black paints contain a considerable amount of sulphur, and where a tin plate has a comparatively light coating the importance of the paint question will be more readily understood when roofers generally are aware of the fact that manufacturers have been devoting considerable attention to the careful study of the effect with different paints freely advertised have when applied to tin roofs. Their observations are corroborated by the experience of old and successful roofers. The conclusions are that some paints will aid in the quick destruction of plates that are heavily coated with tin, no matter what their base may be. These investigations have been going on quietly for a long time, with the certainty that some who have complained of the durability of the tin roof are more responsible than they know for the early destruction of their work. With these facts before them for refutation or verification it remains for the conscientious roofer to discover whether or not the painting materials he is using are likely to cause trouble to his customer, and a complaint for which he is entirely responsible.

ROOF PAINTING

There is money to be made out of roof painting if it receives the attention which its importance entitles it to receive. Too often it is looked on as only a step higher than whitewashing, is done largely for appearance sake and is expected to last only a short time. If roof painting is to be made a branch of a business the same care should be taken to make it do its share in building up a reputation for

good workmanship and serviceable materials as is given to the roof itself, or the heater work, plumbing or anything else that is done by the shop.

The men who do it should be encouraged to feel that their work is important, must be done well; they must not be allowed to think that it is cheap work and "any old way" will do providing they smear over enough surface in a day. They should be required to take care of the materials and tools just as carefully as the bright tin plate is taken care of and the best tools of the other mechanics are cared for. A place and proper provision should be made for storing them so the oil will not waste, the paint cannot harden and the brushes become ruined by drying.

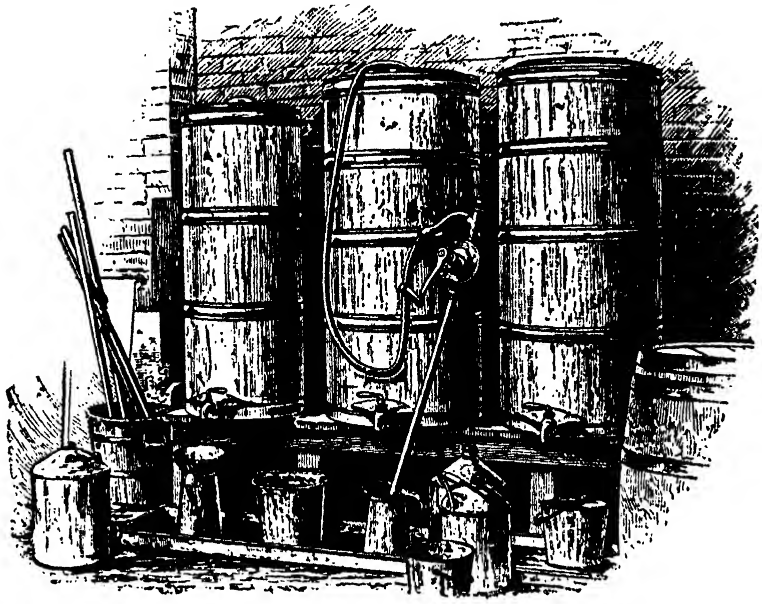


Fig. 175. Roof Painting

The provision made for this purpose, as shown by Fig. 175, has much to recommend it and a view in the part of a shop devoted to the roof painters, which is given herewith, will with the description be sufficient hint to those who make a specialty of roof painting to profit by the example. A strong platform is built about 14 inches high, carried by legs made of 3×4 inch timbers supporting a frame made of the same size of timber, on which the floor of the platform is laid. The legs should be placed so that there will be a space of about 3 feet between them. The platform should be about 30 inches wide and long enough for the oil barrels or tanks.

Tanks made of galvanized iron take up less room, as they can be made higher and of less diameter than barrels and can be kept cleaner. The iron should be of 24 gauge, and if 24 inch iron is used two widths will give ample hight to hold a barrel when the diameter is 20 inches. The bottom can be double seamed on before

the upper body is put on to the lower one. A flaring cover should be double seamed to the upper body and should have a round hole with cover about 8 inches in diameter in the center. Where the upper and lower body slip one over the other at the center a few rivets should be put in to hold them firmly together and then the joint should be heavily soldered inside and outside. A finish and strength is given by putting a swedged band at the top, bottom and between, also well soldered. A brass oil cock large enough to let oil be drawn quickly should be soldered into the body within ½ inch of the bottom and bosses should be soldered on each side to brace it.

The number of tanks required depends on the views held by the roof painter and three will be enough in any case, one for boiled linseed oil, one for raw linseed oil and a smaller tank for Japan drier. Some men mix the two kinds of oil or buy it mixed, and then two tanks are enough. On the floor in front of the oil tank platform a galvanized iron tray or pan should be placed to hold the measures and funnels and catch any dripping. The pan, heavily wired around the top, should be about 1 inch deep and about 14 inches wide and as long as the platform. This will allow the paint can to be placed in the pan while the mixing is done, and will afford a place where paint cans can be kept from marking the floor when in the shop.

A substantial wooden tub or half of a barrel should be kept full of water at one end of the platform, in which the paint brushes may be placed when not in use. They should be kept covered with water so that they cannot dry out and harden, for to do good work in painting the brush must be of good material and soft and pliable, so that the paint can be well rubbed in. A specially made brush on the pattern of the whitewash brush but of better material and thicker is best for the work.

In mixing the paint there is room for some judgment to be displayed and for the body any of the good paints sold by the roofing supply houses will give good service if ground fine. The mixing depends on the time of the year. In the summer a drier is unnecessary if the weather is clear long enough for the paint to set well before a rain comes. Only good linseed oil should be used in summer and for painting it should be mixed in the proportion of 3 gallons of boiled oil to 2 gallons of raw oil, and if for the first coat on a new tin roof it should be mixed thin, so that this coat will dry out thin and hard after it has been well rubbed in. Every part of the roof should be thoroughly covered and care taken to leave no pools or thick coat at any place. If the work is done in cooler months or winter, when a skin will form before the paint can thoroughly dry out, a drier may be used in the proportion of 1 quart of the drier to 5 gallons of oil, more or less according to the weather; less oil when very cold.

A cheap and poor drier should never be used, but always a good drier. After a roof has had a first coat of this kind of paint it should stand six months and then be painted again. For the second coat the paint should have more body but should be rubbed in with the same care, using the drier only when the paint is put on in cold weather. The roof will now stand for three years, when it should receive another coat of paint applied in the same careful manner.

Another important point that must be considered is the condition of the roof at the time it is painted, particularly a new roof. If one of the cheaper, lighter coated tin plates is used it must stand a few days, so that the grease and rosin will come off, and then it must be swept with a stiff broom to get off all the grease, rosin, dust, and particularly rust. If there are any rust spots they should be swept till all rust has disappeared and a clean surface is presented; then the roof is ready for painting. If one of the better old style heavy coated oil flux plates is used the roof may stand a shower or two before the metal is exposed, so as to take the paint properly.

If roofs are treated in this way a guarantee against leaks for a period of time may be given if the roofer has put on the tin with the same care. This guarantee carries a great deal of weight with those who look after the properties of estates and costs nothing if good materials are used throughout with good workmanship and under intelligent supervision. This branch of business can be built up by keeping before those who own roofs the fact that leaky roofs destroy plaster, spoil paint and ruin furniture, besides making the house damp and unhealthy. Leaky roofs destroy themselves, but roofs kept in repair and painted honestly with honest materials will last indefinitely.

EFFECT OF EXHAUST STEAM ON TIN ROOFS

In a condition of this kind the trouble is probably as much underneath as on top, for perhaps excessive condensation owing to the heat of the boilers keeps the underside of the tin wet and again there may be destructive gases from the furnaces.

On top the constant dripping of water from the exhaust pipe keeps the tin in the vicinity of the pipe saturated and in due time the paint cracks and naturally then the tin rusts away.

A positive remedy would be to use copper for the environments of anything which is destructive to tin. Of course the connecting of this copper to the tin roof should be in way to insure no galvanic action between the two metals—tinning this copper on both sides or making the connection by means of lead strips.

TIN ROOFS FROM OUR OFFICE WINDOW

Since so much has been said about the lasting qualities of the tin roof, our attention is given to the roofs which can be seen from our windows, particularly whenever men can be seen on these roofs. Within the recent past we have noted men with steel shovels cleaning the snow from parts of tin roofs, and cannot but wonder whether or not this work done by porters and other laborers is not likely to bring a complaint to the roofer. It is a very natural thing when snow sticks to a shovel for the man to strike the shovel forcibly on the surface cleaned, whether it is a flagstone sidewalk or an IC roof. The marks on the sidewalk very clearly show that even the flagstone has indentations made upon it, and it is reasonably safe to assume that the tin roofs that we are looking down upon have many indentations. Even if there is no hole as the immediate result of the treatment by the snow cleaner, quite probably these indentations will hold moisture which will eventually lead to something more than pin holes when rust gets in its work.

On another roof with a box gutter a young man was seen with a coal hod and a small shovel removing the accumulated dirt from the gutter. Whether this attention to the gutter is the result of a leak or whether some observing man has seen the necessity of it is a matter for conjecture. On the flat roofs in New York City a great deal of cinder ashes and coal dust is carried up from the chimneys and collects on the roof and is washed in the gutter, where it lies to hold moisture for long periods. It is certain that the tin roofer never expected a gutter to withstand such an exposure, even though it may be frequently painted with the best of materials. The suggestion comes to our minds that roofers might frequently find profitable work by calling the attention of owners to the possibilities for trouble and be employed to remove them. There is no doubt but that owners would be saved much needless worry and expense if a few simple precautions such as these were observed. While the instances referred to occurred in New York, the same

slow processes of destruction are doubtless going on in all Northern cities where there are flat roofs.

Several weeks after writing the above we see that sheet metal workers are engaged in patching up the roof in question. From the appearance of the tin where the paint was scraped off there is no fault to be found, but the holes in the plates showed that they were made with a sharp instrument and that burst seams had been hit rudely or stepped on. This is no new thing, but it only serves to show how much needless blame is laid on tin roofing.

A FEW REMARKS ON LEAKS, ETC.

Tin roofs, comparatively flat ones especially, develop leaks not attributable to age and sometimes not to lack of care, thus leaving the roofer open to suspicion as to the quality of material used.

Many of these unexpected leaks are caused by thoughtless boys throwing at random small, sharp-edged rocks and other things with weight enough to cut through the sheet. Some are due to paint blisters breaking and exposing the metal, generally just after a careless person has painted over old blisters instead of breaking them. Some are due to a piece of flashing working out and allowing water to drive behind and under where the metal cannot be repainted, destroying the sheet by corrosion from below. Some are caused by standing seams being malleted down in the direction that throws the inaccessible pocket on the side from which most falling water drives, allowing moisture and dust to collect and cake, which facilitates corrosion. Some are caused by soot and dust, which quickly beds in chimney flashings; and, some result from not thoroughly painting dents, name-stamp depressions, etc., or painting at a time when rain washes off the paint or either dew or frost checkers or pits the surface, destroying the gloss and leaving a surface adapted to retaining moisture.

To insure satisfaction with a tin roof or a valley on a shingle roof, use good material to begin with. Paint the underside and let it dry, then paint it again just before laying in place on the roof. This second painting covers scratches due to handling and causes the sheet to slip without scratching through the dry coat when laying. Use cleats freely and nail them close to the angle. On shingle valleys place a feather-edge wood strip at each side, so the shingle edges at the valley will

project over the strip and be held off the metal an inch or more. This avoids much capillary dampness, allows repainting back under the shingle ends and admits air where it is most needed. Paint valley tin on both sides and dry and paint again below before laying. Give all tin work a coat of paint as soon as the work is done. A roof should have the second top coat when the first is thoroughly dry.

If any holes are found, made by something falling on the roof or by nail-heads wearing through from below, and no tinner is convenient, paint the places and nail trunk or tar-paper roof washers over them, well bedded with putty. This is shown in Fig. 176. Two methods of placing the strips for valleys mentioned before are illustrated in a conventional manner in Figs. 176 and 178, the former being adapted to old work where the roof or valley is to be renewed. The valley shingles may be raised from the tin, as shown in Fig. 178, by using thinner boards for the valley than those of the regular sheathing.

To repair a roof with paint skins clean off the roof by removing all peeled paint, dirt, etc. Over the defective spot give a coat of metallic paint. With a

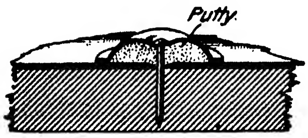


Fig. 176. A Temporary Patch on a Tin Roof

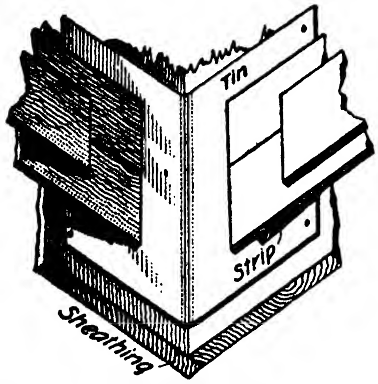


Fig. 177. Wood Strips on Valley to Raise Shingles and Prevent Tin from Rusting

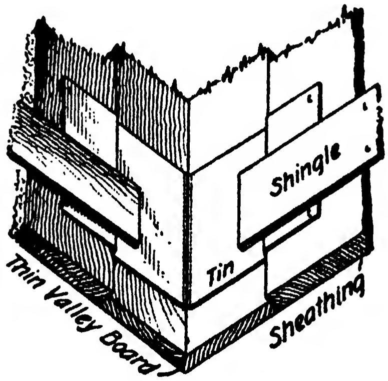


Fig. 178. Thin Valley Strip to Raise Shingles off Tin

trowel spread on one side of a piece of unbleached muslin of the required size a layer of paint skins or roofing cement, and place it over the defective spot, pressing it down firmly. Spread another layer of cement on top and smooth it down to the lines of the roof. Over all this give a liberal coat of paint.

The only way to make a good job of relining the valleys on a slate roof is to remove the slate, take up the old valley and lay the new one under conditions which will facilitate good work being done. It is a matter of little importance whether tin or galvanized iron is used if the sheets in both cases are heavily coated and well protected. It would be practically impossible to slide a new valley lining in over an old one, so as to avoid buckling and make a good job of it.

TIN ROOF REPAIRING

Roof repairing is not a pleasant task by any means, and a good mechanic usually dislikes such work. Too frequently, however, this work is entrusted to the poorer class of workmen and to the younger hands, with results that are satisfactory neither to the employer nor to the house owner. Too much of such slighting of work will result in loss of custom, most of which pays better than new work. It will not be denied that job work, roof and gutter repairs included, returns a larger and more certain percentage of profit than contract work, for which perhaps several have competed.

Such custom, then, should be cultivated, and it is not enough merely to advertise "Repairs Carefully and Promptly Done." It is necessary to convince people of that fact by actual experience. The proof of this has been demonstrated many

Jonesville, N. J., Sept. 1, 1942

Mr. Wm Jones

DEAR SIR:—Wet snow and melting ice will find leaks in a roof which is impervious to a shower of rain. It takes longer and costs more to repair roofs and conductors in cold weather than in mild weather. Are YOUR roofs and rain spouts ready for the winter?

A coat of good paint at the proper time will often save the price of a new roof. We employ the BEST MEN and the BEST MATERIALS. Both Phones.

Respectfully yours,

Plumbing, Heating, and Tinning.

J. TINNER & CO., 63 B. St.

Fig. 179. A Timely Hint

times by such directions as the following: "Now, Mr. Tinner, your competitor, Mr. Roofer, sent two boys up here two weeks ago, and although he has sent me a big bill, the roof leaks worse than ever." They always say the roof leaks worse, although it would be safe to assume that it doesn't. But let that pass; the real point is to do your work so that it can't leak.

A disagreeable feature of roof repairing, and one which cannot be entirely overcome, is that the orders for such repairs are most plentiful when autumn is changing into winter, and there is little desire for an out of door life high up in the air. Moreover, this overplus of repair orders conflicts with other work which is seasonable at this time, such as heater, furnace and steam work. In order that this embarassment of good fortune may be a little more evenly distributed, a form like that given in Fig. 179 may be printed on postal cards in typewriter style.

Emphasis is placed on this style of type, as we believe a plain announcement of this kind is more effective than a display "ad." of the same size. It will be easy to suggest variations from the form presented, such as a letter sheet inclosed in an envelope, with a good engraving of a scene representing water dripping through a handsomely painted ceiling on to a carpeted floor, etc.

It sometimes happens that a customer insists on knowing the cost of repairs before the work is begun. The uncertainty of such work requires that an average section, comprising one-third or one-fourth of the entire roof, be laid off, and this section be carefully gone over, one sheet at a time, and the leaks located plainly with chalk. By counting the leaks thus marked and adding to the number to allow for the portion not marked, a fairly safe basis for calculation may be obtained. A good price for the work should be set, as it is safe to infer that your competitor is not in the game, particularly if he has been ineffective in a former attempt at repairs.

It is poor policy, as well as dishonest, to induce a customer to repair a roof which the judgment of the mechanic would condemn; and if the nature of the leaks is such that a definite guarantee of a useful life for a reasonable time cannot be given, the customer should be plainly informed of that fact. For instance, if the leaks are mainly split seams, caused by the expansion and contraction of the tin, the conclusion is obvious that, although the roof may be tight for a time, other seams will open and cause new leaks from the same cause. The owner should be apprised of that fact; and the better way to do so is by letter, retaining a carbon copy to guard against future trouble.

A good and trustworthy mechanic should be given full charge of the job, and furnished with sufficient help to run the job along with speed enough to prevent its becoming a distasteful burden. A good plan is to have the best man hunt for and mark all the leaks, taking one sheet at a time in regular courses across the roof; another tinner to repair the leaks, and a boy to prepare them for soldering. It will be found that the best tinner will find the leaks much faster than they can be repaired. Two sets of soldering tools on the roof will, therefore, be necessary. If the boy does the work of preparation well the three will be kept busy, as he will be able to prepare the leaks as fast as the two tinners can solder them.

Taking it for granted that the roof is old and protected with several coats of paint, a gasoline blow torch should be used to burn off the paint where it is necessary to scrape for soldering. This makes the work of preparation quick and easy, although the one using the torch should be cautioned not to poke the hot blaze into a hole in the tin. The writer was once compelled to hold down the metal

capping of a ridge on a row of fine dwellings, the sparks meanwhile traveling along the tinder like dry rot under the metal, while the boy who caused the mischief went down two sets of ladders after a bucket of water. As the boy was instructed not to hurry while in sight of the servants, nobody else knew of the danger.

To prevent the flame of the torch from scorching the paint on the tin further than necessary, a strip of asbestos cardboard should be cut, with a slot of the proper width, as shown by the cut in Fig. 180, and the heat applied to the unprotected portion only long enough to permit of the easy removal of the paint by the scraper. When no blow torch is at hand a paint burner can be used. This device is shown in Fig. 186 which readily explains itself. It is made of black sheet iron, with $\frac{3}{8}$ in. holes punched as shown. To this is riveted four legs of band iron so as to raise the bottom of the burner about one inch from the tin. The heat is obtained by using charcoal. A few hot coals are first taken from the fire-pot and placed in the

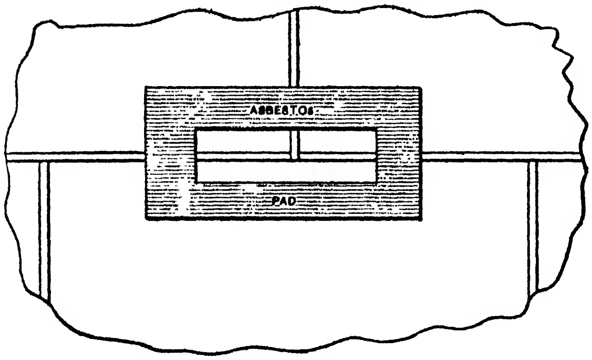


Fig. 180. A Torch Pad for Paint Burning.

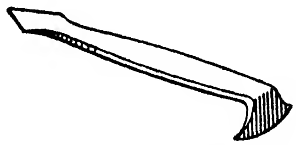


Fig. 181. A Cleaning Scraper

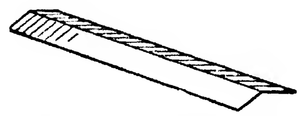


Fig. 182. A Seam Cap

paint burner, after which other charcoal is broken into pieces the size of a hen egg and placed over the hot coal, the burner being filled with these to the top. The draft which is created through the perforations soon has the coal in a blaze. The burner is then set over the spot to be repaired. In a few minutes the paint blisters and can be cleaned off with a cloth. A good scraper for the purpose may be made from an old 10 or 12 inch flat file, shaped as shown in Fig. 180. Both edges of the spear shaped end and the curved edge of the hoe shaped end should be sharpened. It is important that the ends of the split seam leak be well cleaned and scraped, as carelessness in so doing will result in the entrance of water beneath the new repair.

The method so often followed of piling on solder to cover a leak in a split seam is unsatisfactory in several respects. The leak is likely to open again through the solder, on account of bubbles blown in by the moisture during the soldering; and if the leaky seam occurs in the gutter the raised ridge of solder holds back the

water. Less solder is required and a better repair is made by capping the split seams with strips of good tin cut about ¾ inch wide and slightly bent lengthwise through the middle in the folders, as shown in Fig. 182. The edges of the tin need not be nailed down or prepared in any way, except that the strips should not be kept on hand long before they are used, as they solder much better with the edges freshly cut.

A leak caused by a nail head pushing up through the tin should be covered with a cleat nailed down over it with a single nail as shown in Fig. 183. Where it is necessary to fasten down tin which has bulged up and broken away from its fastenings, screws should be used, with the same kind of cleats.

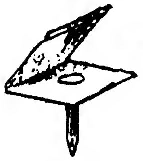


Fig. 183. A Nail Cap

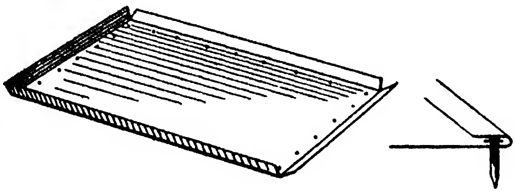


Fig. 184. Fastening Down a Patch

Where it is necessary to place a large patch, the old tin should be cut away nearly to the size of the new patch and building paper placed under the new tin. The new patch should be blind nailed and soldered carefully. For a reasonably flat roof the ordinary method of blind nailing is to turn up the edges of the patch on all sides, nailing through the tin just inside the turned up edge and battering down the turned up edges so as to cover the nail heads, as shown in Fig. 184. For a long patch near the edge of a roof, where a good appearance is an object, or on a steep roof, the upper side of the patch may be blind nailed so that the edge presents the same appearance as a lock seam, as shown in Fig. 185.

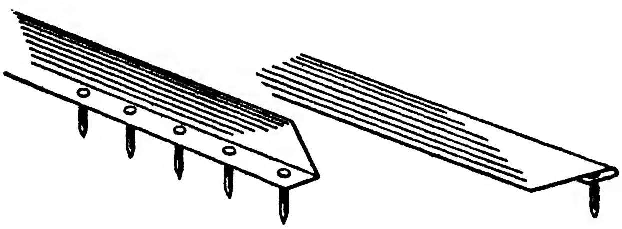


Fig. 185. Blind Nailed Edge Patches

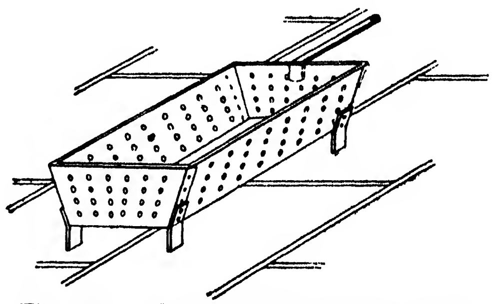


Fig. 186. A Substitute for the Blow Torch

After the marked leaks have been repaired it is well to give the roof another close examination, remembering that the customer pays for the time, while, if called back to repair a forgotten leak, there is likely to be a dispute as to who should pay for the extra time, with the added humiliation of "taking two bites at a cherry." When the repairs are satisfactorily completed the acid may be washed from the places repaired and the patches painted.

It is not a fool's job to locate the leaks in a tin roof, and combinations of timbers, boarding and roofing papers are sometimes found which will tax the ingenuity of a smart man. The place where the water enters through the ceiling may be, and often is, at some distance from the actual leak in the roof. When a troublesome leak cannot be located by the ordinary method of measuring above and below, the tinner is justified in cutting up the tin at the suspected spot, when an examination of the under side of the tin may reveal the trouble in numerous small pin holes, or at least lead to a search in the proper direction.

An interesting chapter might be written by almost any roof repair man on peculiar leaks. An instance was when called upon to locate a leak some time ago where two stories intervened between the ceiling where the leaked showed and the roof. A quantity of fine cutlery was injured by it. There was a steam radiator directly over the goods damaged, but the family renting the flat stoutly insisted that the air valve had not been touched, and pointed to the dust on the floor as an evidence of the truth of their statement. The dust certainly did look natural, but after a search, which covered every possible source of trouble from roof or cornice, cutting up the floor it was found that the plastering, joists and even the under side of the flooring was thoroughly soaked with water from the radiator. While all roof leaks cannot be attributed to radiators, here is evidence that the roofer may be called upon to discover the cause of water damage or have his reputation and the roof suffer by imputation.

CONDENSATION TROUBLES—I

One of the most common of the many troubles of the roofer is condensation on the under side. It often causes the utter ruin of the tin in an amazingly short time. Many times the roofer is called to stop puzzling leaks which are nothing else than the drip of the condensing interior atmosphere. And it is hard to convince the average person that the roof is tight and the leak (?) nothing else but aforesaid drip. Again, spots appear on plastering which is not due, though always blamed on the roof, to a leak but the chemical composition of the plaster and exceptionally humid condition of the air.

Much has been said relative to this phaze of the roofing business and a few of the remarks from experienced men are reprinted here. From the opinion of many

experts it is well to remember the following rules when doing roofing work:

Always see to it that the space under the roof is thoroughly ventilated.

If because of the purposes of the use of the building there is a likelihood of the air being in a continuous saturated condition and will come in contact with under surface of the tin, then lay on the sheathing a dependable waterproof paper absolutely free from anything in its composition injurious to the tin. This paper to be laid from the top down so should there be a leak it will run under the first seam of the paper and become manifest underneath instead of being held by the paper and be apt to start rusting of the undersurface of the tin.

Protect a tin roof already down by covering the underside of sheathing with a waterproof paper thereby protecting the tin and perhaps obviating condensation by keeping the inside air from striking a cool surface.

CONDENSATION TROUBLES—II

The superintendent of the building called up to-day, and said one of the copper decks was leaking around the ventilator. Went up and looked it over. We were careful to have the copper turned up 3 in. all around the vent opening, and the corners carefully soldered before the vent, a 24 in. one of standard pattern, was set. It was held in place by stays on the inside and to insure against snow blowing into the vent was soldered to the roof all around.

The small space between the copper flashing turned up inside the vent and the sides of the vent base had filled with condensation, and finally overflowed into the building. A nail hole was made in the vent base on each side to let the water out, and a small piece of copper bent in a semicircle and soldered outside the holes, with the top and bottom edges free, allows egress for the condensation and prevents snow blowing in.

Had a lively argument with the superintendent of the job, when we told him there was no leak, and he triumphantly asked why the vent on the other end of the building did not "leak," as had been the case with the one he complained of. We replied that it was because the other end of the building was not being plastered. Therefore there was less moisture in the air to condense, and we took him to the other end of the building and showed him where the water was slowly dropping from the weep holes we had made, and he had to admit that he was learning a few things about roofing that he did not know.

ROOF CONDENSATION TROUBLES—III

The architect had an argument with me last week and could not be convinced that there was no leak in the valley on the north wing of a building where we did the work.

This wing is several feet lower than the main building, and the ridge of the roof of the wing runs into the slope of the roof of the main building, but most of the roof below the ridge stops against the wall of the main building. A valley starts 15 ft. out on this ridge and finishes at the bottom at the corner of the main building, making a triangular section of roof running to a point at the low end where the valley intersects the corner of the main building, and for 10 or 12 ft. up the roof we put on a copper watershed.

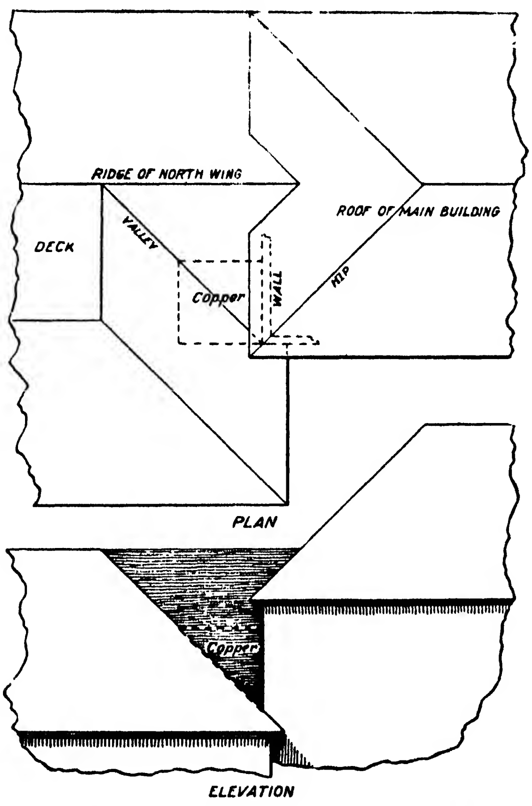


Fig. 187. More Condensation Troubles

This sketch, Fig. 187, shows the layout of the roof and valley. Near the bottom of the valley the sheathing was wet inside the attic, but there was no snow, ice or water outside, and had not been any for several days as I had noticed this and formulated my theory before the architect kicked about the "leak." Several days earlier the sheathing had been wet underneath this valley all the way down, and also underneath the whole of the copper watershead, the wet section following the lines of this work because of the facility with which copper conducts heat away and therefore cools off the warm air inside and causes condensation when the air outside is very cold and the warmer air inside is very moist.

In this case these two extremes existed as the weather was very cold and the air in the building very moist from escape at air valves in the steam heating system and the drying of the plaster, so the sheathing became wet from the condensation. Naturally this followed down the rafters, and the sheathing at the low points became saturated while that near the top of the valley and the top lines of the

watersheds did not get so wet and soon dried out when conditions improved, while that near the bottom remained wet longer and it was the dampness at that point which was reported as a "leak."

I explained this to the architect, but he would not believe it entirely, and said he would have to see a rain on the roof before he would believe the condensation theory. I then examined the watershed, valley and roof thoroughly, and was firmly convinced that there was no leak. The rain this morning showed the architect conclusively that there was no leak, as a very heavy rain, continuing for several hours, failed to let any water through, and he had to admit that he was wrong.

ROOF CONDENSATION TROUBLES—IV

A complaint made by the superintendent of a large building in course of construction, and being plastered, was that there were some leaks in the roofs on one side of the building beyond the wall line. The roof is of slate, over single ply tarred felt, and the eaves project beyond the building about 4 ft. The weather was quite cold; the building is heated and the air is very wet from the drying out of the plaster and a number of open valves from the heating radiators.

The openings into the attic are large and numerous, allowing all the moisture and saturated warm air to rise to the attic, from which there was little chance for egress, as nearly all the ventilator dampers were closed. In the attic we found that on the east side of the building, the overhang of the eaves outside the wall line between the rafters, was wet, except about every tenth space, which would be found to be dry. We then examined the eaves on the west side of the build- and found them all dry.

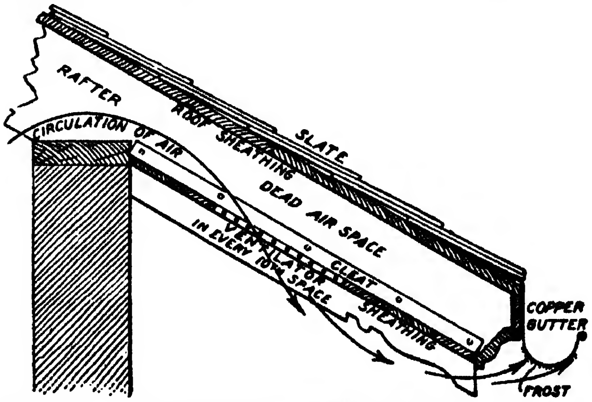


Fig. 188. Explanation of Alleged Roof Leakage in Attic

As stated, the eaves extend beyond the walls of the building about 4 ft., and there is dead air space between the rafters about 6 in. high and the distance of the overhang, as cleats were nailed to the sides of rafters as shown in accompanying sketch, Fig. 188, and to these cleats were nailed sheathing boards, as shown. To the tops of the rafters, about 6

in. above, was nailed the roof sheathing. The lower side of the space was closed by the molding nailed to the ends of the rafters. The upper side, on a line with the inside of the wall, was open.

My theory was that the dead air spaces shown condensed the moisture from the saturated air, because extending beyond the wall line, this space was much colder than the rest of the attic. The superintendent derided this theory and asked why every tenth space was dry. I replied that this was one proof of my theory, as this tenth space was the one in which a perforated ventilator was placed in the lower sheathing just outside the wall line and the circulation of the air in this space prevented the condensation of the moisture.

Then we went outside and I pointed out to him proof No. 2 of my theory. There was frost on the copper gutter just outside each ventilator opening where the warm, moist air from the vent opening struck against the gutter and was condensed on it in the form of frost. Proof No. 3 was that there was no snow, ice or water on the roof, and had not been for several days.

A fourth proof was that on the west side of the building, where the construction was just the same, there was no complaint of "leaks" and no moisture showing on the under side of the roofing sheathing. This was because the sun was shining on that side of the building and the air in these spaces was warm enough to hold the moisture in suspension. The superintendent and the architect are beginning to think that they will not be able to catch us with the "goods on us" on any leaks on the job, for whenever they have complained their complaint, like this one, has been traced back to condensation and proved to their satisfaction to be due to that cause.

There will be no trouble from that cause after the building has been in use, because, first, the attic will not be nearly so warm, as the openings into it will be closed, and second, the air will never be nearly so wet as the drying out of the plaster and the leakage from open radiator valves has kept the air saturated.

A ROOFING CLEAT BENDER

A roofing cleat bender which in one motion bends the roofing cleat ready for use on the roof, turning a ¼-inch edge on one end and making another turn 1¼ inches from this end is shown by Fig. 189. When the cleat is to be used on the

roof, all that is to be done is to place the $\frac{1}{4}$-inch edge on the cleat over the $1\frac{1}{4}$-inch edge which has been turned on the course of tin for the standing seams and to drive the nails through the wider end at the bottom of the cleat. Take a piece of hard wood 1 inch thick, 3 inches wide and 6 inches long. To this secure another piece of hard wood $1\frac{1}{4}$ inches wide by means of a small wrought iron hinge at each end. To the $1\frac{1}{4}$-inch piece fasten with screws a handle with an offset in it at the center. To the wider piece of wood fasten by means of wood screws an upright piece of wood at each end, and to these uprights is secured a piece of hard wood, the bottom side of which was placed just $1\frac{1}{4}$ inches above the top of the pieces to which the hinges were fastened. Then fasten by means of wood screws two piece of heavy sheet iron to the bottom piece, one piece 1 inch wide and the other $1\frac{1}{4}$ inches. The holes are drilled in these pieces of sheet iron so that the edges of both are fastened even at the back. Fasten them to the wood so that the narrower piece of iron is on the under side and the front edge of the wider piece is flush with the front edge of the board. Now, by putting the piece of tin that was cut off for a cleat under the edge of the sheet iron and bringing the handle of the cleat bender in an upright position, the two bends are made and the cleat formed in one movement.

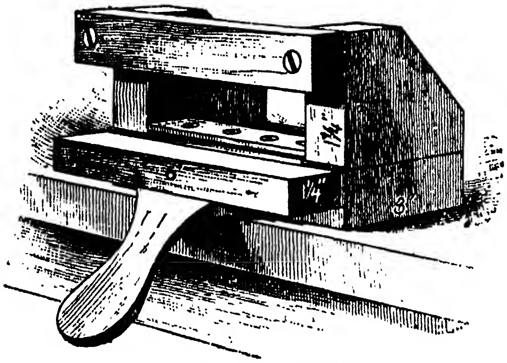


Fig. 189. A Roofing Cleat Bender

ROOFING LADDER

This ladder known in trade parlance as a "chicken ladder," has its convenience enhanced by the adjustable bracket. The bail makes the bracket secure, while the bolt prevents it from dropping from the ladder when moving about on the roof. The slotted plate through which the bolt passes is placed under a smaller slot cut in the top of the bracket. Only a round hole large enough to pass the bolt should be bored in the ladder, thereby holding the bolt firmly in the ladder, while the slot allows enough play to the bracket to prevent the leg of the bracket from climbing the roof, as ladders with a fixed bracket will do while working upon them.

By removing the thumb screw the bracket will be free to slide upon the ladder, and the bail can be lifted and placed under any cleat desired to move the ladder up out of the gutter, and the bracket is refastened by putting the bolt through one of the other holes which have been previously bored for the purpose. Fasten the cleats to the ladder with No. 8 wire nails, setting the clinches well up in the wood so as not to scratch the roofing plates. The cleats are fastened 12½ inches apart. In Fig. 190 is shown the finished ladder with the bracket at the top, and Fig. 191, shows the bracket. It will be noticed that by means of a hole under the different cleats the ladder can be adjusted to different lengths of rafters. It is

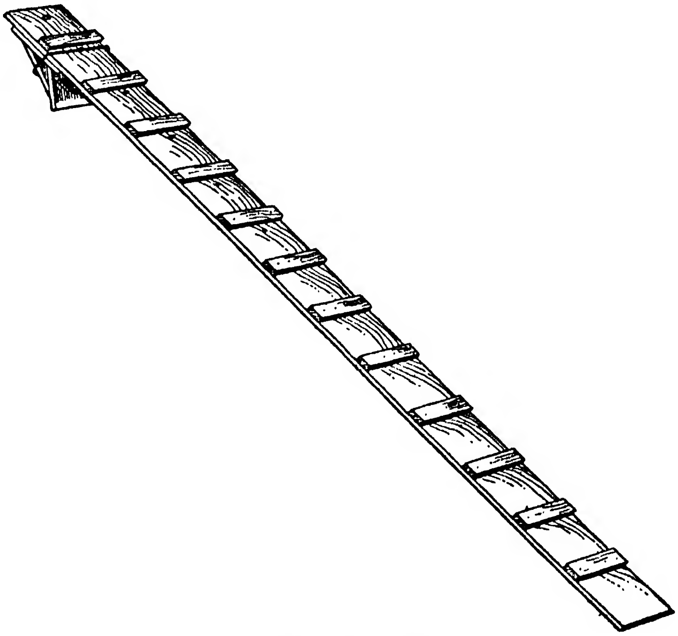


Fig. 190. Roofing Ladder—Ladder Complete

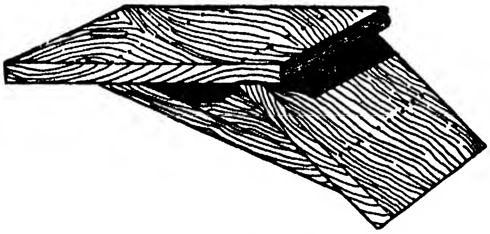


Fig. 191. Ladder Bracket

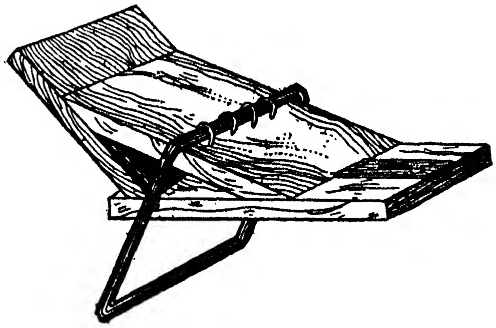


Fig. 193. Bracket and Bail

made from pine board 16 feet long, 7⅞ inches wide and ⅞ inch thick. The cleats are 7⅞ inches long, 2½ inches wide and 1 inch thick. The bracket top is 12 inches long, 7⅞ inches wide and ⅞ inch thick, while the bracket leg is 8 inches long, 7⅞ inches wide and ⅞ inches thick, and the bracket brace, connecting the two parts is 11 inches long, 7⅞ inches wide and ⅞ inch thick. The bail, Fig. 192, is 8 inches square, formed of 5-16 rod, welded solid. The bail is stapled to bracket brace,

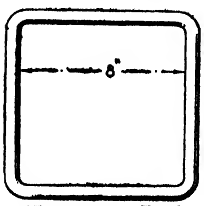


Fig. 192. Bail

Fig. 194. Bolt and Thumb Nut

as shown in Fig. 193, with barbed wire fence staples. Fig. 194 is a carriage bolt 5-16×2½ inches, which is used for fastening the bracket to the ladder, as previously mentioned. The iron plate shown in Fig. 193 is 2×4 inches, screwed to the underside of bracket, with slot in both plate and bracket through which the bolt passes down from the ladder, the thumb nut, Fig. 194, being screwed up next to the iron plate.

ROSIN SCRAPER

In the accompanying illustration, Fig. 195, is shown what is known as a wire brush, which is used in practice as a rosin scraper. Before the seams in tin roofing are soldered the rosin is usually burned on the seam, and after soldering the rosin flows considerably. It is often the case after painting a tin roof, where the rosin had not been scraped off, that the rosin cracks and exposes the tin plate and causes it to rust.

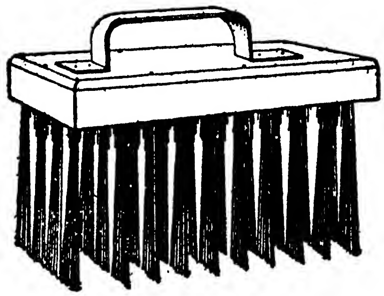


Fig. 195. Rosin Scraper

To avoid this after the roof is soldered, and before painting, use a wire brush, as shown in the illustration. The brush has a wooden top and a leather handle into which the hand is slipped. By working the brush backward and forward with little force the rosin is removed, making the roof ready for painting. By using the brush a considerable amount of time is saved compared with using a penknife or flat scraper.

SHEET STEEL MORTAR SAW

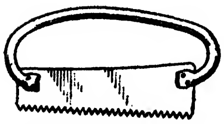


Fig. 196. From an Old Carpenter's Saw

The general custom of cutting the joint in brickwork for the insertion of the edge of the flashing is to cut away the mortar with a hammer and chisel. A quicker method is to make a saw as shown by sketch, Fig. 196. It is operated back and forth in the joint. Oftentimes these saws are just made from heavy scrap iron with the top folded round shape to act as a handle.

COMBINATION SCRAPER AND TIN CUTTER

When repairing tin or galvanized iron roofs, after the defective sheets have been found, it is usual to use a chisel and hammer and cut out the defective spots, and then use a scraper with which to scrape a smooth, bright surface on the old tin or iron, so that a joint can be made with the new metal.

Or a case may arise where an old tin roof is being ripped up to make place for a new roof. Before cutting, the old tin roof is usually divided into sections, cut and measured, rolled up and tied and the size number of square feet in each roll marked on the outside, so that in case a piece is wanted of a given size, it will

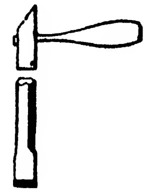


Fig. 197. Slow Method of Cutting a Tin Roof

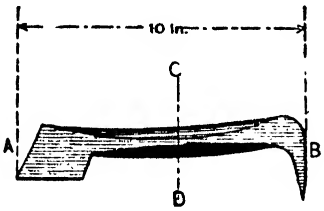


Fig. 198. Side View of Combination Scraper and Tin Cutter

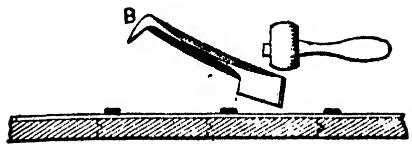


Fig. 202. Section through Tin Roof Showing Cutter in Use

not be necessary to open the roll again for measurement. If defective sheets, or an old tin roof, were to be cut out, using the hammer and chisel shown in Fig. 197, a great amount of time and labor would be lost. To avoid this, and have the scraper and cutter combined in one, there is shown in Fig. 198 a side view of a combination tool for the purpose. The cutter shown at A is used to cut out the old sheets, and the scraper shown at B is used to obtain a bright surface on the old

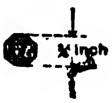


Fig. 199. Section through C D


Fig. 200. End View of Cutter at A

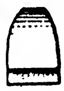


Fig. 201. End View of Scraper at B

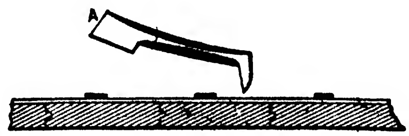


Fig. 203. Section through Tin Roof Showing Scraper in Position for Use

metal. The scraper is made from ¾-inch octagon steel, and, as shown in Fig. 198, should be 10 inches long when finished.

Any blacksmith or tool maker can make the scraper to order, Fig. 198 giving a good idea of how the tool should look when finished. Fig. 199 shows a section at the line C D shown in Fig. 198; Fig. 200, the end view of the cutter shown at

A, and Fig. 201 the end view of the scraper, shown at B. Fig. 202 is a section through a tin roof with the cutter in position when in use.

It will be noticed that the end B is raised so that the point of the cutter touches the roof. In practice the tool is grasped near the end B with the left hand, and taking in the right hand an old mallet, which has already done its duty in pounding down locked seams in tin roofing, the blows are struck as indicated in Fig. 202, moving and striking the gutter alternately.

Fig. 203 also shows a section through a tin roof with the scraper in position for use. In using the scraper, the end A, Fig. 203, is raised as shown, and, taking the scraper in both hands, a downward pressure is exerted, at the same time drawing the scraper backward and forward until a smooth, bright surface is obtained.

ROOFERS' ELEVATOR

Here is an illustration, Fig. 204, and description of a roofers' elevator that can be used with satisfaction in the absence of something better for hoisting rolls of tin to a roof instead of carrying them up a ladder. It should be made of oak, 1½ inches thick and 6 inches wide, one part 3 feet long and the other part 2 feet long. Buy a 14 inch extra heavy strap hinge, a pulley wheel 4 inches in diameter with a ½-inch hole in it, and a ½-inch bolt, 6½ inches long. In the short piece of oak at one end saw a slot in the middle of the 6-inch side, 6 inches long and wide enough for the pulley wheel to turn easily. Bore a hole for the bolt to hold the pulley wheel and secure them in place. Fasten the two parts together with the strap hinge and it is ready for use. A strap made of band iron with holes in each end for screws or nails to hold it on the roof should also be provided when a considerable quantity of tin is to be raised. Standing on the long part will answer for raising a few rolls. In use, all of the short part hangs beyond the edge of the roof and a rope runs over the wheel to the ground, with a hook on the end for fastening to the roll of tin. By pulling on the rope on the roof it works easily over the pulley, raising the tin until the roll strikes the short part of the elevator, when an up pull will make the hinge double back and drop the tin on the roof.

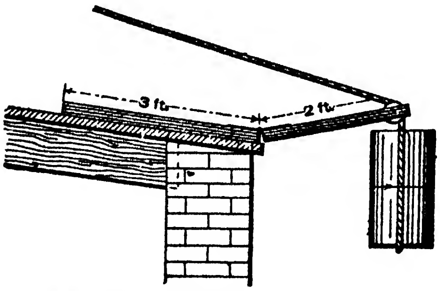
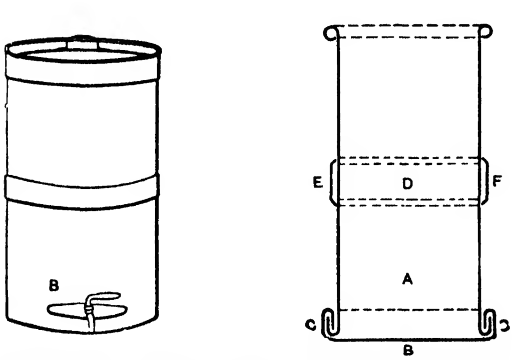


Fig. 204. Elevator in Operation

CONSTRUCTING AN OIL TANK

In Fig. 205 is shown a perspective view of an oil tank. The constructive view is shown in Fig. 206, in which A is the body, double seamed to the bottom of B at C C. A heavy wire edge is placed at the top, as indicated. Galvanized sheet metal bands are soldered at intervals around the tank, in this case only one, D, being shown. They are made as shown at E F, a ¼-inch edge being bent at an angle of 45 degrees at each side of the strip, and the strip being equal in length to the circumference of the tank. These beveled edges are now soldered direct to the tank, to prevent buckling and to secure stiffness.

The patterns for the tank are all rectangular pieces, excepting the boss, which secures the faucet shown by B in Fig. 205. This pattern is obtained as shown in Fig. 207, which shows a quick, accurate rule which requires no triangulation, the



Figs. 205 and 206. View and Section of Tank

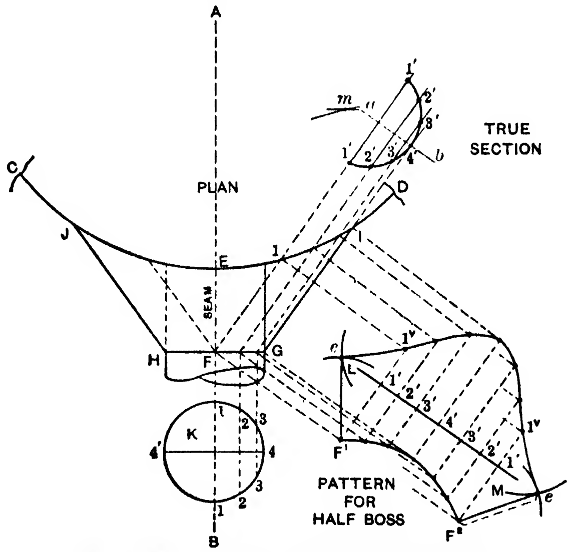


Fig. 207. Pattern of Boss for Faucet

pattern being developed by means of parallel lines. First draw the line A B, and with A on this line as center, having the required radius of the tank, describe the part plan C D. Locate the hight of the boss as E F and draw the diameter of the faucet G H. Locate the distance that the boss should project on either side of the tank as at J and I, and draw the lines J H and G I.

In its proper position below the line H G draw the profile of the outside of the faucet, as indicated by K, one-half of which divide into equal parts, as shown from 1 to 4 to 1, because in this case a seam will be placed along E F, and therefore in practice only one-half plan is required. From the various intersections in

K erect vertical lines intersecting H G as shown. From these points parallel to G I draw lines indefinitely intersecting the curve C D, as shown. While K represents the true profile on the line H G, a true section must be found at right angles to G I as follows:

At right angles to G I draw the line *a b*. Now measuring from the line 4 4′ in the section K take the various distances to points 1, 2 and 3 and place them on similar numbered lines, measuring in each instance from and on either side of the line *a b*, as shown from 1′ to 4′ to 1′, which is the true section required.

For the pattern take the girth of the section just obtained and place it on the line L M, drawn at right angles to G I, as shown from 1′ to 1′. Through these points draw the usual measuring lines, intersecting them by lines drawn at right angles to G I from intersections on F G and E D, and resulting in the shape F^1 1^v 1^v F^2 The triangular piece shown by E 1° F in plan is transferred to the pattern as follows: With radii equal to F E and 1° E in plan, and F^1 and 1^v, respectively, in the pattern as centers, describe arcs intersecting each other at *e*. Now with A E in plan as radius, and 1^v and *e* in the pattern as centers, describe arcs cutting each other at *m*. Using *m* as center and using the same radius draw the arc 1^v*e*. Then F^d *e e* F^2 will be the pattern for the half boss, which must be formed after the true section shown.

This is presented for those who may desire to make the tanks shown in the article on Roof Painting, as receptacles for the oil and dryer necessary for roof painting.

SECTION VII

(Pages 785-900)

SKYLIGHTS AND LOUVRES PATTERN LAYOUTS

Practical Sheet Metal Work and Demonstrated Patterns

FLAT SKYLIGHTS

Although flat skylights involve the elementary constructive characteristics of the entire category of skylights, they are nevertheless the fundamentals in the matter of constructive features, and much time and thought have been expended in experiments to simplify the design and learn a mode of expeditious handling.

The cardinal principals to remember when designing a skylight of any class are: To design it of ample strength to resist imposed stresses or loads; sections or profiles of curbs, bars and the like must be as simple as consistent with required strength to allow of rapid forming into shape on the brake, and the girth to be such that they will cut out of the sheets without waste.

There are several kinds of flat skylights. Fig. 1 is a picture of the most common style, that which is set on a roof curb of sufficient hight above the roof to insure imperviousness to storms, the roof to have the necessary pitch. A longitudinal section is shown in Fig. 3, giving a design, with a bar of 2-in. depth, that has proved adequate for skylights of a size up to 8 ft. wide.

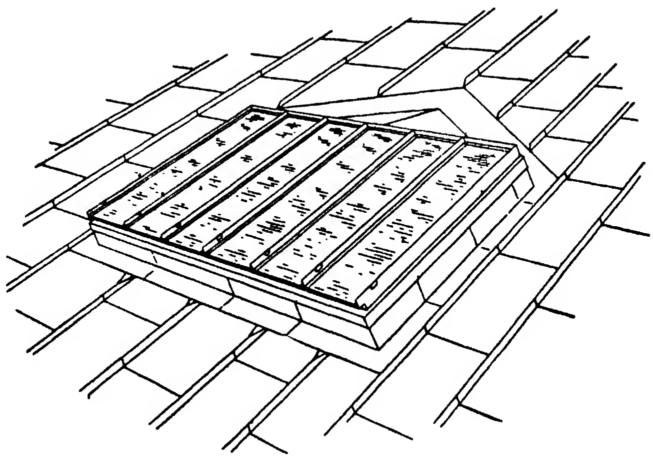


Fig. 1. General view of Flat Skylight

It is to be understood that the construction of a roof governs the length of skylights, for by proper anchoring of bottom curb of skylight to roof curb any length may be built, though the drainage of the roof back of the skylight is then to be considered. In this case it is customary to employ the built-in type, which allows the water on the roof back of the skylight to run over it rather than to be conducted to the sides of the skylight by the saddle, as indicated in Fig. 1.

Naturally by reinforcing bars with core plates, as shown by Fig. 4, the length of bar can be increased over the 8 ft. just mentioned. Should, however, the length of required bar be considerable, it is advisable to abandon the type of Fig. 1, and instead of enlarging the bar section and reinforcing with a core plate in the built-in type of skylight, the roof should carry the load by a system of purlins on which the skylight bars rest. The purlins should be spaced apart the distance bars are calculated to be self-sustaining; for instance, with the bar of Fig. 3, purlins would be 8 ft. apart.

The obtaining of the patterns for the skylight of Fig. 3 entails no intricate methods of developing, the principal requisite being to be constantly on the alert for means of strengthening and simplifying the joints; as at A, B, C and D of Fig. 2, which is a plan of the joints of the skylight, minus the glass and caps.

Therefore, for the pattern of the side curbs of the skylight, take the stretchout of profile A, Fig. 3, and place it on the line X Y. Draw the customary parallel lines through these points and from point of profile A drop lines to intersect like numbered lines of line X Y. This, then, is the pattern of the joint A of Fig. 2 for the side curbs, laps being allowed as shown dotted. This also, without the laps, is the pattern for the upper curb, the cut of the pattern being the same at both ends.

For the miter cut of the side curb at the joint B of Fig. 2, drop lines from profile B, Fig. 3, which is the lower curb, to those on line X Y in this manner: From 7, 8 and 6 of B the line will intersect 9, 8 and 7 of the pattern as shown, also from *a* of B to 6 of the pattern.

Following the simplifying idea, profile B from *a* to 0 will be a straight cut; that is, it will butt against the upright member of profile A 6 5. Hence, the cut on the side curb from 6 to 5 will conform to that part of profile B from 4 or *a* to 2. It is, therefore, necessary to take the distance 4 *a* to 3 *b* and place it from 6 toward 5 of the pattern, as shown. A line projected from 4 of B, also from 2, will give that part of the cut; the rest of the cut of the side of profile A is straight to 4, then from 4 to 3 it goes back to suit 3 *b* to 2 of profile B, and is then straight. The gutter of the side curb 3 2 1 is cut on the slant shown to allow the condensation in the gutter of the side curb to drain into that (5 4) of the bottom curb. After making several of these skylights it was found that the laps are best placed as indicated by the dotted lines.

The pattern for profile B, or lower curb, at the joint B of Fig 2, will be the same at both ends, and is obtained by placing its stretchout (profile B, Fig. 3) on the line V W and drawing the usual parallel lines as shown. Project lines from profile A, at 8 and 6, to intersect 8, 7, 6 and *a* of the pattern; as aforesaid, the

rest is a straight cut, so this will be the pattern of lower curb, with laps allowed as shown.

For the pattern of the bar, or profile C (at joint C of Fig. 2, first), proceed as follows: Place the stretchout on line T U and draw the lines through the points. The vertical numbers 5 4 and 5 6 will be a straight cut; the shoulders, or glass rests, 6 7 and 3 4, are cut back to miter on the shoulder 2 3 *b* of profile B. The members of C, 3 2 and 7 8, are straight cut, to butt against 4 3 *b* of B. The gutters of C, 0 1 2 and 8 9 10, are cut as described for the gutter 0 1 2 of A.

The cut of profile C at joint C, Fig. 2, is best obtained by using the same stretchout, U T, and drawing a line parallel to U T, as *r s*. The vertical members, 4 5 and 5 6, of C are straight, as shown, and are on the line *r s*, to butt against 4 5

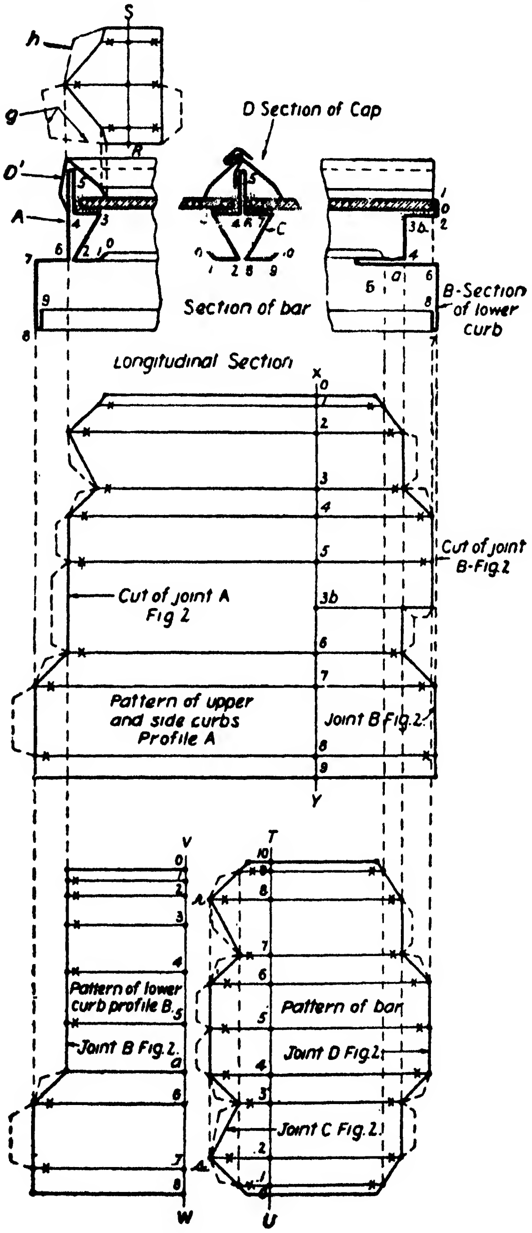


Fig. 3. Patterns for Bars, Caps and Curbs

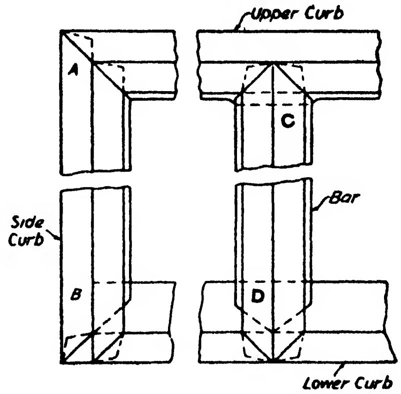


Fig. 2. Plan of Joints of Skylight

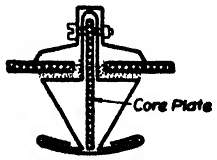


Fig. 4. Bar with Core Plate

of A. Then the shoulders, 6 7 and 4 3, are cut to suit those of profile A, 4 3, and the depth of the cut, which is 4 3 of A, is taken with the dividers and stepped from

line $r\ s$ of the pattern and on lines 3 and 7. The gutters of bar c would be cut straight, but are here cut on a slant to prevent interference when assembling, because the gutters of the bar are set on top of that of the curbs. Allow laps as shown by the dotted lines.

The caps should be formed as indicated by D for the bars and by D^1 for the side and upper curbs; lower curb, of course, having none. For the pattern place the stretchout of profile D (same for D^1) on the line R S, and the parallel lines drawn through the points on this line are intersected by lines projected upward from the profile D^1. This will be the cut of the miter of the bar caps with those of the upper curb. No laps are necessary and at the bottom the cap would have a straight cut, the cap terminating at 1 of the lower curb B.

The side caps are cut straight at the bottom and one-half would be the same as for the bar caps, the other half being cut as shown by the dotted lines g. The caps for upper curb are of a length to fit between the bars. The spacing of the bars should never exceed 24 in., eighteen in. being a good average, for glass is not even self-supporting throughout when lying in, or nearly to, a horizontal plane, and would break of its own weight. The upper caps then would agree to this width and one-half would be cut as shown by lines g, the other half by line h, both ends of the cap being cut alike.

The caps are held in place by soldering the upper caps to the curb, then to these the side and bar caps, they being held to the glass by copper cleats, which were previously soldered to the bar, about 8 in. from the lower curb.

In Fig. 5 is portrayed the manner in which an ornamental effect was acquired on a church roof by turning the skylight cornerwise. These offer less obstruction to the flow of the water on the roof than the other type and snow seldom, if ever, banks back of these. This, as is evident, created some trouble for the carpenter in the framing of the roof, which, however, was not formidable; as for the skylight, it was just a matter of changing the procedure a little, to wit:

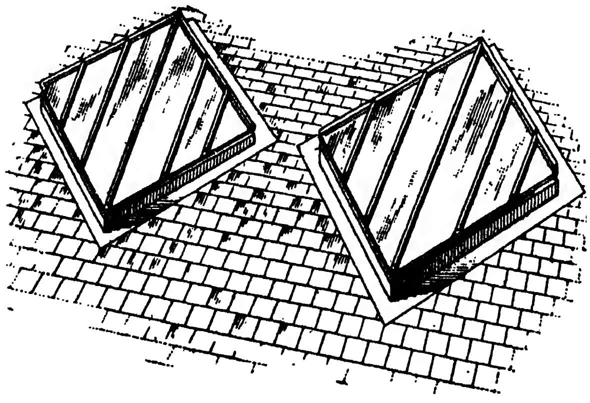


Fig. 5. Flat Skylights on a Church Roof

The two upper curbs were the same as (profile A) in Fig. 3, each having the miter cuts of side curbs of Fig. 3 to miter on the two lower curbs of Fig. 6, which are of the profile B of Fig. 3. For the miter at the extreme lower corners of the skylight of Fig. 6 another pattern of

profile B of Fig. 3 was necessary, which was a square miter, obtained by the principle of cutting any square miter.

In all a plan would be as shown in Fig. 6. This plan was necessary in the development of the patterns of the bars and caps, new ones having been required

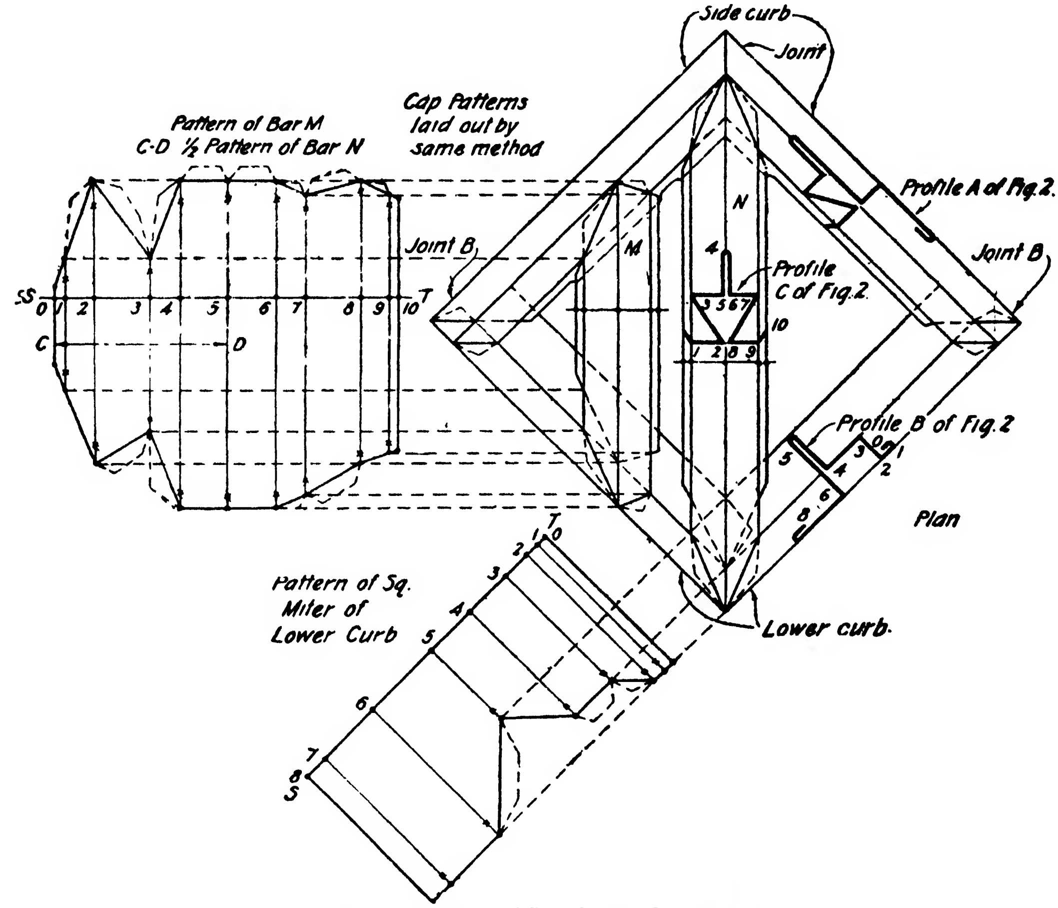


Fig. 6. Method of Developing Patterns

owing to the bars mitering on the curbs at an angle; the development should be quite clear by a study of Fig. 6. And it is of interest to state, this style of skylight will cost about 10 per cent. more than the ordinary one shown in Fig. 1.

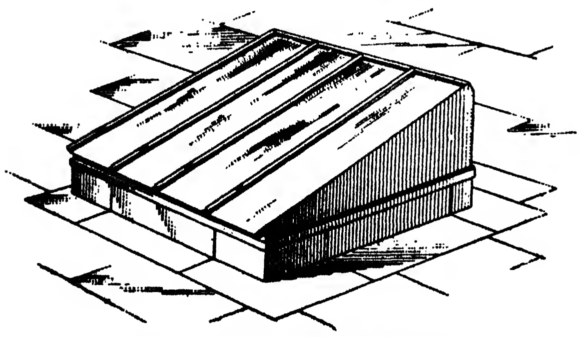


Fig. 7. Single Pitch Skylight

Oftentimes there is not sufficient pitch in the roof curb. Fig. 7 shows a skylight with a single pitch for such a roof, as it is desirable to have pitch conducive to rapid drainage of the glass surface. The deficiency in such a case can be met by raising the upper curb of

the flat skylight, all but the part known as the apron (and its shoulder), 9 8 7 6 of profile A, Fig. 3. The space from 6 to 5 is then filled out. Of course the weight rests on the sheet metal constituting this filling in and, perforce, the skylight size should not exceed, say, 4 ft. in width, when 4 in. to the foot is given as pitch.

A longitudinal section of this skylight is given in Fig. 8, together with the method of allowing for the pitch in the pattern of the side curbs on line 6 of the pattern of the side curb, Fig. 3. It is to be understood that for the top curb the compensation for the pitch would be also on line 6, but instead of a triangular filling it would be rectangular and of the hight of the altitude of the triangular piece; in other words, the cut V of Fig. 8 is the same on both sides for top curb. There would be no change in the pattern of the lower curb (B, Fig. 3), except to bend on the line *a* of Fig. 3 to the angle prescribed by the section in Fig. 8. If wanted, the skylight size or the pitch may be greater than stated if the top curb is reinforced, as suggested

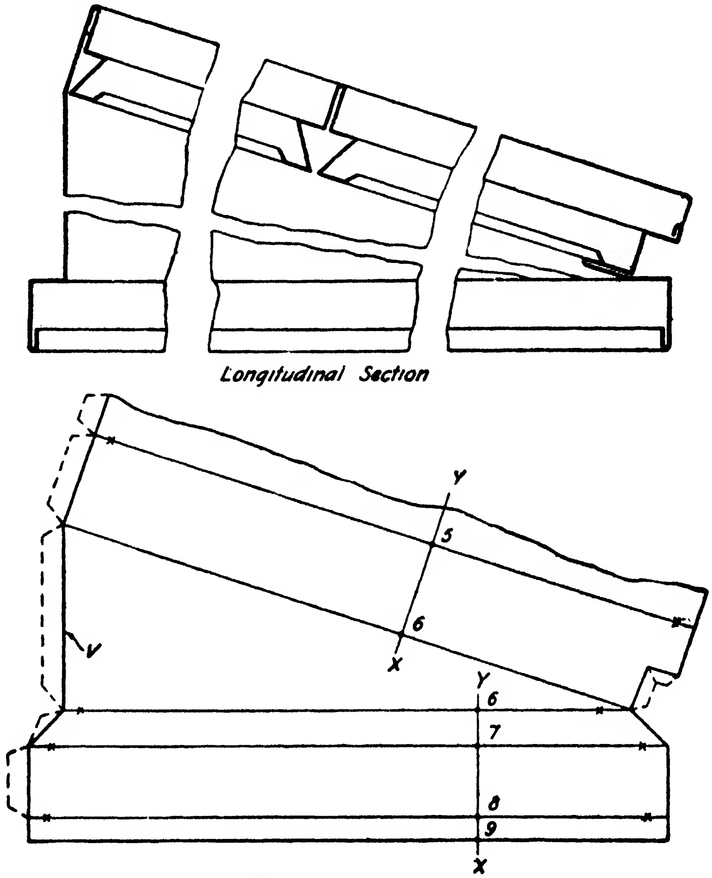


Fig. 8. Method of Compensating for Pitch in Pattern

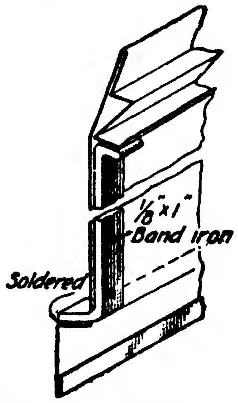


Fig. 9. The Reinforcement

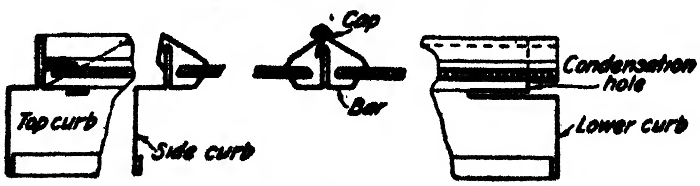


Fig. 10. Longitudinal Section of Puttyless Skylight

by Fig. 9. A new design commensurate with requirements is recommended, however, as it is impossible to guard against collapse when just the sheet metal is depended on to resist compressive strains, even if reinforced.

Hundreds of small lights of this type and of a size up to 4 ft. wide are made to need no putty. These are decidedly cheap, though absolutely weathertight and substantial in the size mentioned. The design is shown by the sections in Fig. 10, which answer for both, that with and without a pitch. The patterns are obtained as described for the other types.

MAKING FLAT SKYLIGHTS

It is the intention in this exposition to elucidate a well tried procedure of making flat skylights from the cutting of the material to shipping to the job. The explanation is based on methods used by a large concern in the manufacture of skylights. A skylight 7 ft. 9 in. × 15 ft. 3 in. will be used as an example, this size being about as large as is advisable to make wholly in the shop. Fig. 11 gives the sections of a typical flat skylight, and as it is of interest to explain the working of the modern power press,

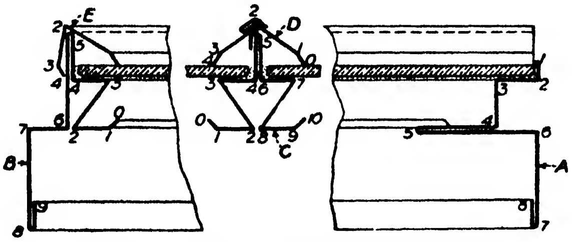


Fig. 11. Section of a Typical Skylight

the bending operations of the parts of the skylight will be shown for both the hand brake and the power press.

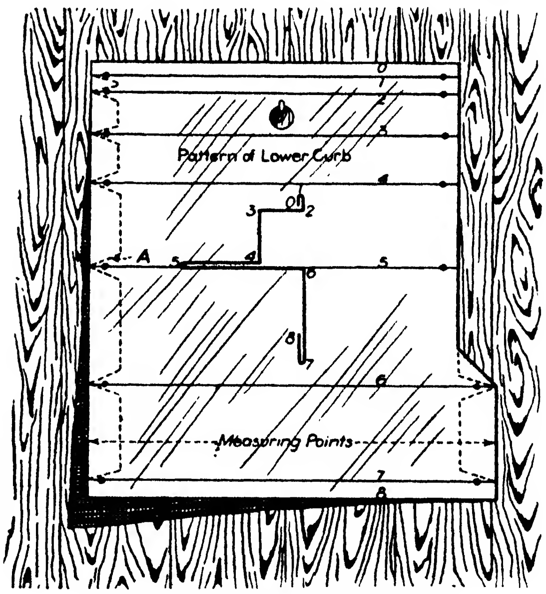


Fig. 12. Sheet Metal Stub Pattern

It is customary to preserve stub patterns of sheet metal for the standard types of skylights. These stub patterns are like the one shown by Fig. 2, which is that of the lower curb. And to allow of cutting without waste, skylight sections are designed to be of a girth that is an equal divisor of the standard stock; for instance, assuming that the pattern of Fig. 12 has a stretchout of 7½ in. it would cut four out of a 30-in. sheet. Having this set of stub patterns no further laying

out of patterns is necessary, except to make a scale layout of the skylight on which is shown all dimensions as indicated by Fig. 13. From these data the material can be cut, for if the sketch states, for example, that a skylight is wanted 7 ft. wide, the lower curb would be cut 7 ft., measuring on the parts of stub indicated thereon; and so on for all parts.

A putative job of 100 skylights of the size of Fig. 13 is required, for which the accompanying Requisition List will read as shown. Therefore, the procedure of making the skylight is as follows: The back gauge of the large square shears is set to, say the girth of the lower curb pattern, 7½ in. This gauge is the same on the foot and the power shears, and the sheet is cut by pushing it through and between the cutting blades until it strikes the gauge, when the treadle is brought down, throwing in the clutch for the power machine, thereby making cut by the descent of upper blade; or with the foot machine causing the descent of the upper blade by the leverage of the foot treadle. This is repeated three times, and the piece remaining should be 7½ in.

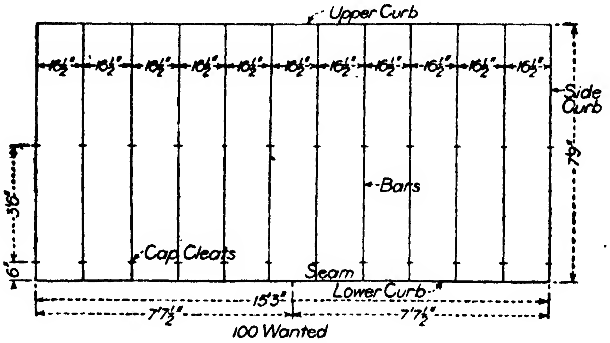


Fig. 13. Layout of a Flat Skylight

REQUISITION LIST

200—Lower curbs (right and left)	Size as shown
200—Side curbs (right and left)	Size as shown
200—Upper curbs (right and left)	Size as shown
200—Side caps (right and left)	7 ft. 8¼ in.
1000—Bars	7 ft. 8¼ in.
1000—Bar caps	7 ft. 8¼ in.
1100—Top caps	16⅜ in.
2400—Soft copper cleats	2 × 1 in.
1100—Lights of $^3/_{16}$-in. ribbed glass	16 × 92 in.
30—Tubs of linseed oil putty	(110 lbs tub)

It is better practice to trim all the sheets, allowing for greater ease and accuracy in the final cutting operations. To do this the girth is reduced on the stub patterns ⅛ in., which will give ¼ in. to trim from each side of the sheet. As this is always preferable, then, instead of pushing the sheet at once to the back gauge, the ¼ in. is trimmed off by setting the front gauge 29¾ in., and holding to that first. And after the fifty sheets are cut, and keeping the last strip of each sheet aside, the front gauge is set to the 7⅜-in. mark and the old edge trimmed

from these strips. This is preferable to endeavoring to cut the last strip with the back gauge, for even if another man holds the strip in back, or the strip is held by an arrangement on the back gauge, the operator's fingers are endangered, and besides the cutting blades are strained owing to the inability of the holddown attachment of the shears to grasp a ¼-in. edge. This cutting operation is repeated for all the parts of the skylights, using 8 ft. sheets, for that is the best length to cut from for this size skylight.

There are two methods of cutting the miters on these strips, which are now called unfinished blanks, either by dotting off with a sharp punch and scribing the outline with a sharp awl from the pattern to each blank successively and cutting with the snips; or by a press with the proper dies which stamp out in one blow the entire miter cut, and if necessary make the punch mark for bends. If the press is used, the blanks must be cut square at the ends and to the right length, for say with the bars 7 ft. 10 in. long and the dies requiring an allowance of ¾ in. for each miter, the blanks will be 7 ft. 11½ in. long. It is immaterial whether the 30-in. sheet is cut to this length first or the blanks are; it having been found that an operator can handle the blanks with greater speed and accuracy than the sheets, compensating thereby for the four edges cut at once with the sheet, whereas but one is cut in trimming the blank. This trimming is better done on the 36-in. square shears with the customary bench and gauge attached for long sheets. And of course this ends the cutting of the parts, excepting when the blanks are cut with the hand snips they should be dressed down with a mallet, holding them on a smooth surfaced iron for the burr arising from cutting and the upstanding punch marks interfere with the bending operations. These then are the finished blanks, though in the matter of spacing the bars two methods are pursued, either to dot off the spaces on the glass rests of the lower and upper curbs, which is ideal, for after one set of curbs has been spaced the marks can be pricked to each blank from this set, a saving of incalculable time, especially if blanks are cut by the snips. The other method of spacing is to use a gauge of a length coincident with the space between bars; this gauge is made by putting a couple of bends in a piece of iron to stiffen it; and in assembling, bars are held to this gauge.

One of the most difficult descriptions for the pen, is that of bending operations relative to forming sheet metal into the various profiles that it is possible to shape this material. Not only that, but it becomes monotonous to write and read continuously the phrase, "reverse insert in brake and bend on dot No. 4." In consequence the explanations will be graphic rather than written, the diagrams being relied on more than the text. For the lower curb, profile A, Fig. 11 begin

bending operations as follows: Insert 7 to 8 in the brake and close clamp B, Fig. 14, on dot 1, bring bending leaf A up, until it strikes the clamp B; this operation from now on will be called "all the way." Lower bending leaf, release clamp, push bent part in brake, close clamp which squeezes tight the hem edge as shown, in Fig. 15. Pull blank out to dot 2, bring bending leaf up square as shown

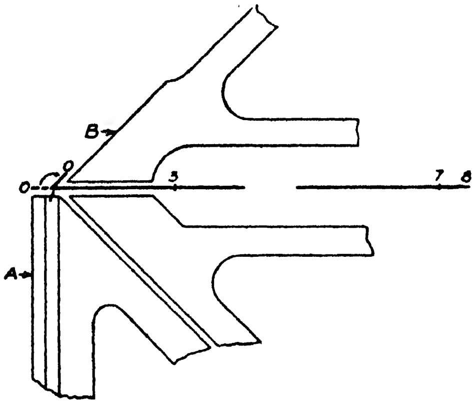


Fig. 14.

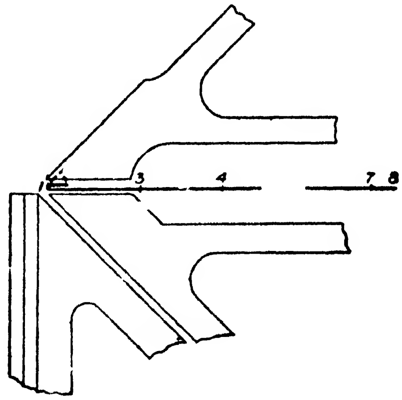


Fig. 15.

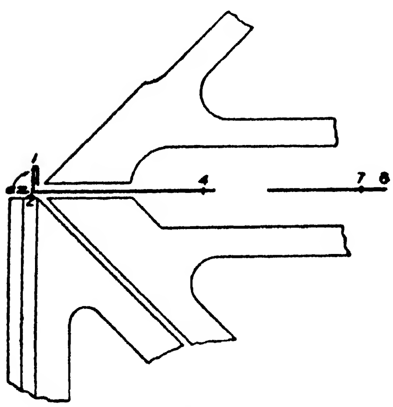


Fig. 16.

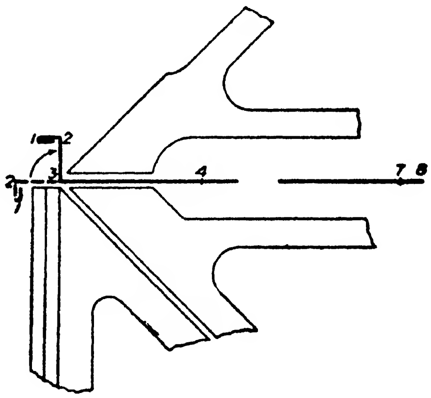


Fig. 17.

First Bending Operations for Lower Curb

by Fig. 16, called in the rest of text, "bend square." Remove blank all the way out of the brake and grasping it in the center, turn it end for end, that is, bring the left hand end of the blank to the right hand end of the brake; this is to be known after this as "turn round." Insert in brake, bend square on 3, Fig. 17. Take out, turn around, bend square on 4, Fig. 18, turn around, bend all the way on 5, Fig. 19. Turn around, bend all the way on dot 7, Fig. 20. Insert this in the brake and close, as Fig. 21. Turn around blank and bend on dot 6, Fig. 22. Place bend 5 in the brake and close, as per Fig. 23, which is the final operation for the bending of the lower curb.

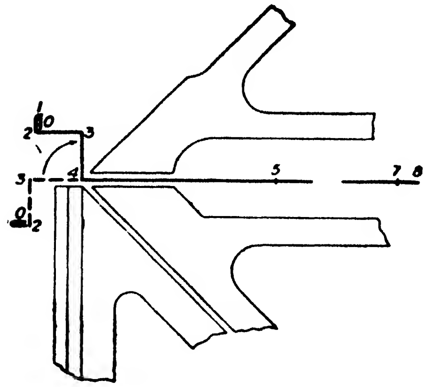


Fig 18.

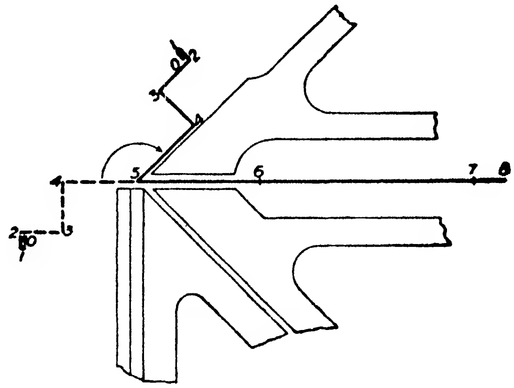


Fig. 19.

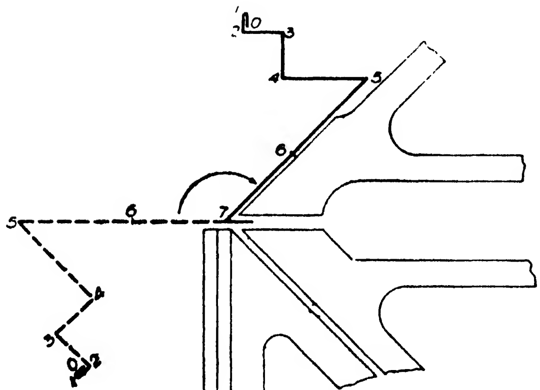


Fig. 20.

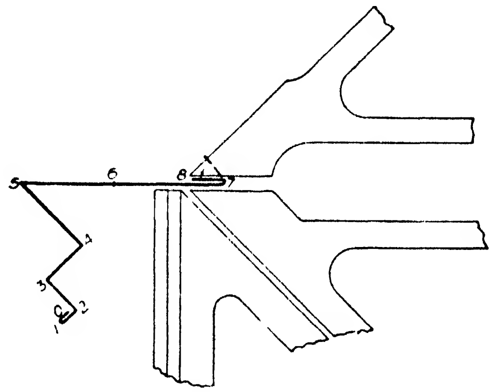


Fig. 21.

Continued Operations for Lower Curb

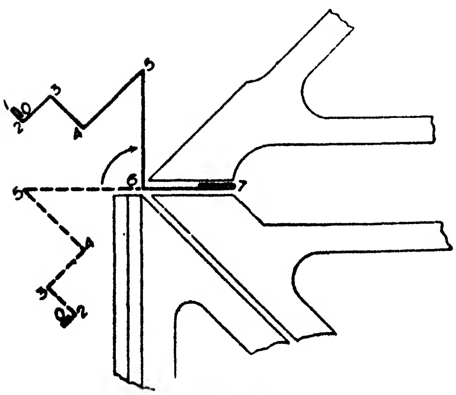


Fig. 22.

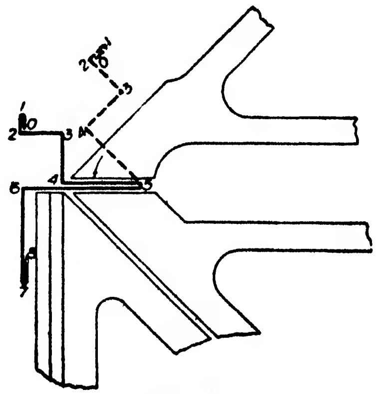


Fig. 23.

Final Operations for Lower Curb

Profile B of Fig. 11 is formed by starting on dot 4 with 9 to 5 in brake and making square bend, Fig. 24. Remove from the brake and turn bottom side of

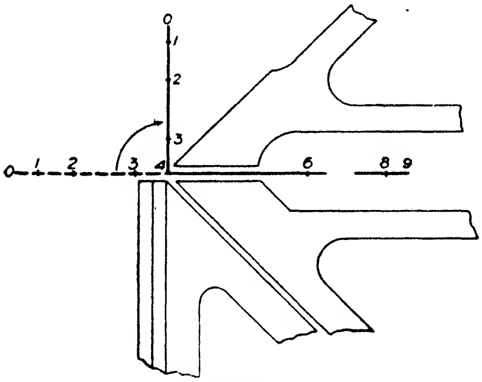


Fig. 24.

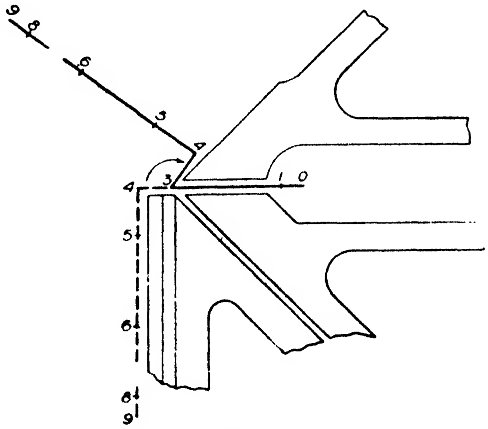


Fig. 25.

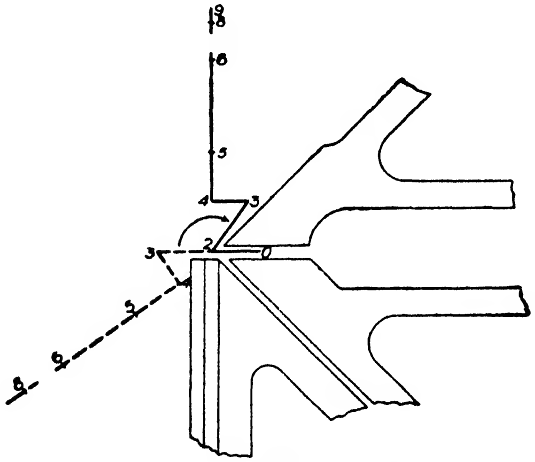


Fig. 26.

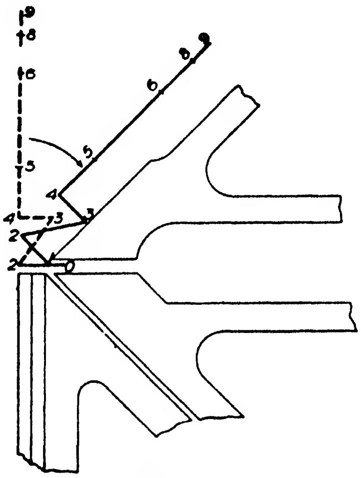


Fig. 27.

First Bending Operations for Side Curb

blank up and insert 0, 1 and 2 in the brake (to be known hereafter as "turn over,") bend to required angle on 3, Fig. 25. Turn around, bend dot 2 to angle, Fig. 26. Remove blank to 1 and make the bend, bringing the bending leaf up carefully and stopping when the bend on dot 3 strikes the clamp of brake, as Fig. 27. Turn over blank and make bend on dot 5 all the way, Fig. 28. Turn blank around and bend square on 6, Fig. 29. Turn over and squeeze bend on dot 5, Fig. 30. Turn the blank around and bend all the way on dot 8, Fig. 31. Push this bend in the brake and flatten as Fig. 32. Push into the brake and make bend on dot 7 square as Fig. 33. This completes the forming of the upper and side curbs. Sometimes if material is heavy it is impossible to close the clamp on the entire bend, in which case one end only is inserted, and this much flattened,

then a little more placed in the brake and closing the clamp, and so on. This, of course, is likely to close the bend irregularly; therefore, it is advisable to exert the utmost strength and close clamping leaf on the entire bend.

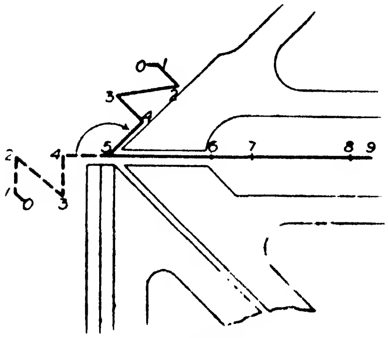


Fig 28.

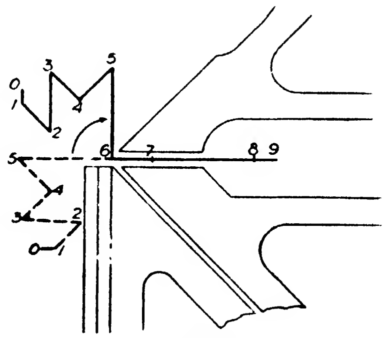


Fig. 29.

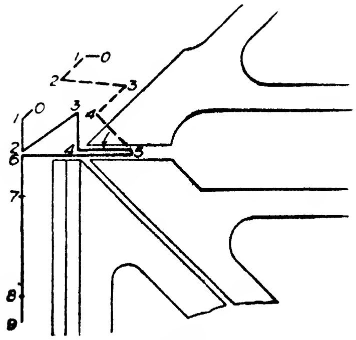


Fig. 30

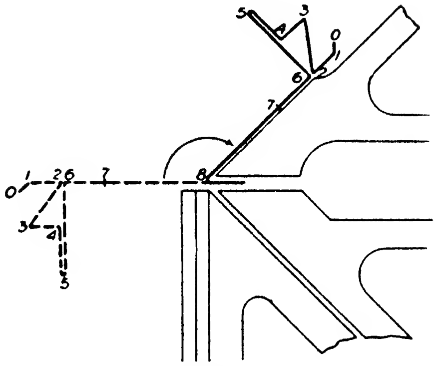


Fig. 31.

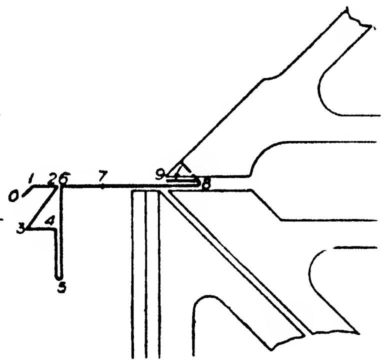


Fig. 32.

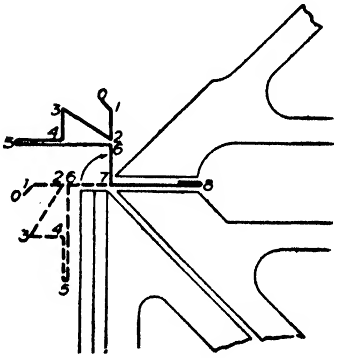


Fig. 33.

Continued and Final Operations for Side Curbs

The bar, profile C, Fig. 11, is formed by commencing at dot 6, with 7, 8, 9 and 10 in the brake and bending square, Fig. 34. Turn over the blank and bend 5 all the way as Fig. 35. Turn the blank around and bend square on 4, Fig. 36.

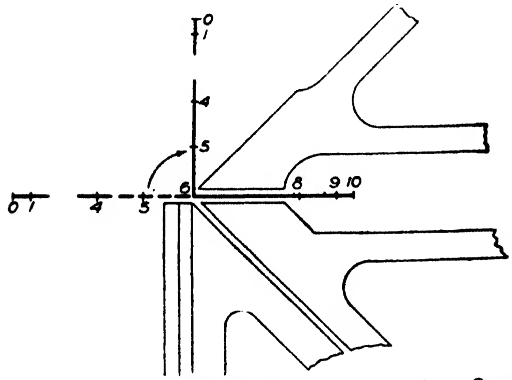


Fig. 34.

First Operations for Bending the Bar

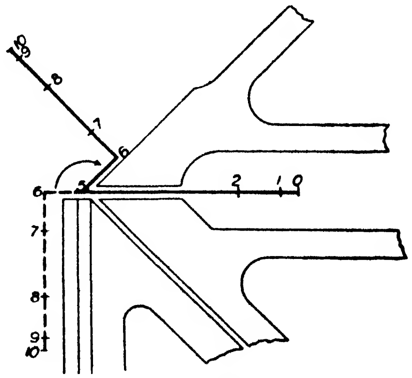


Fig. 35

It is possible that some forcing will be necessary to have dot 4 pass the bending leaf owing to dot 6 striking the face of bending leaf. With some machines the face plate A is in two parts, one being removable which will allow dot 4 to pass as shown. Turn over and bend on dot 7 to the required angle, Fig. 37. Turn the blank around and bend dot 8 to angle, Fig. 38. Bend 9 as shown by Fig. 39. Turn over and bend 3 to angle, Fig. 40. Turn the partially completed bar around and bend 2 to angle, Fig. 41. It will require a little forcing to get dot 2 into the brake. However, by removing plate A this forcing amounts to but little, for the spring of the metal is such as to allow this forcing. It is to be understood that the plate A may be left off during all operations, providing the material to be formed is not extra heavy, which would spring the bending leaf. Some brake operators close bend on dot 5 with their hands as shown by Fig. 42. This assists in the complete closing of the bend in the brake; and naturally these remarks apply to all similar bends. Bend dot 1 as shown by

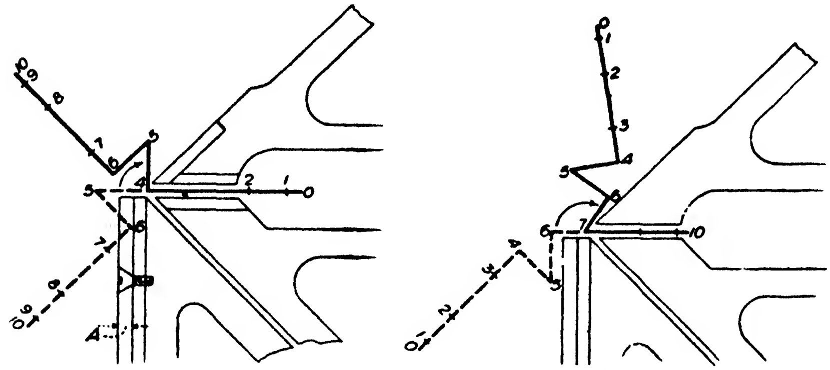


Fig. 36. Fig. 37.

Continued Operations for Bar

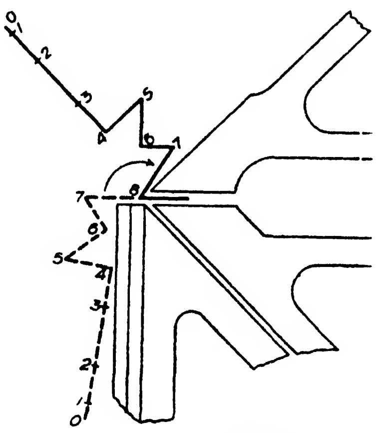


Fig. 38.

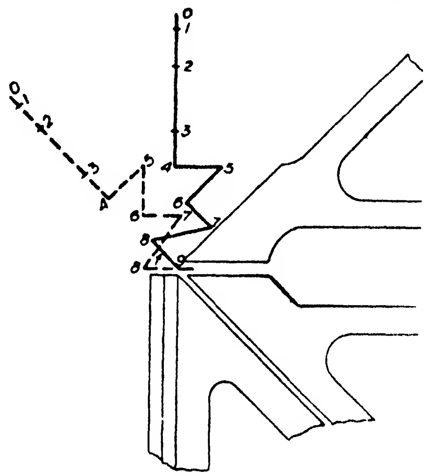


Fig. 39.

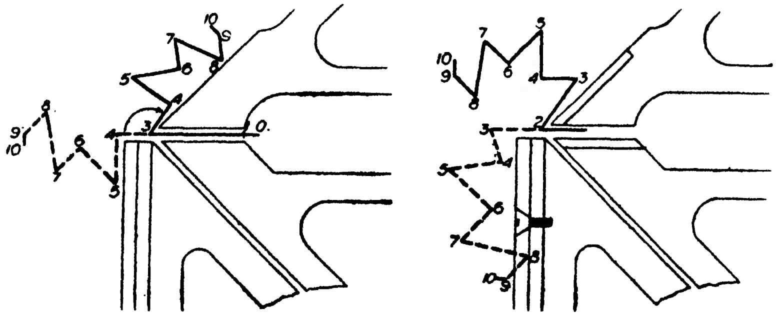


Fig. 40. Further Operations for Bar Fig. 41.

Fig. 43, then close bend on dot 5 as per Fig. 44, completing the forming of the bar.

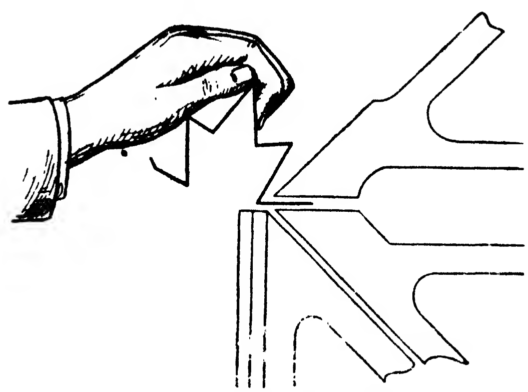
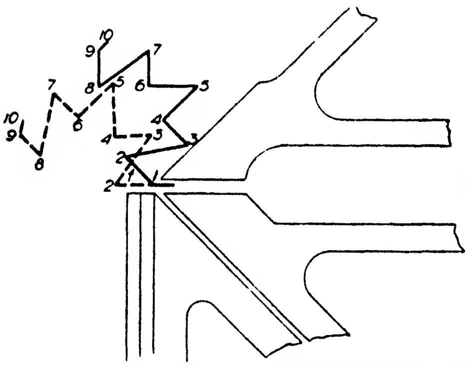


Fig. 42. Closing the Thumb Bend with the Hands

It should not be out of place to state here, that the usual method of gauging the angles of bends, or rather determining just how far to raise the bending leaf for such bends as Fig. 37, and having found the distance to have a gauge for subsequent bends of similar angles, is by a quadrant and adjustable stops as illustrated in Fig. 45. Having set the stop, it can be turned down so that bending leaf may go beyond it for different angle bends; but experience has taught that in the rapid manœuvering of the operator, he invariably forgets the stop when making the next bend which has the bending leaf passing the stop, and crashes into it, and consequently the stop is moved up because of the blow, even if no injury results. It has been observed that skilled brake hands discard these stops and quadrant, contending that they are always in the way; and to guide them they make chalk marks on the bending leaf, indicated by Figs. 45 and 46.



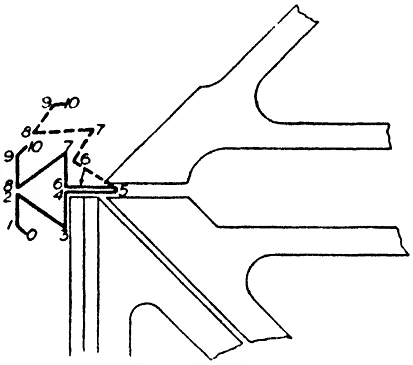


Fig. 43. Final Operations for Bending Bar **Fig. 44**

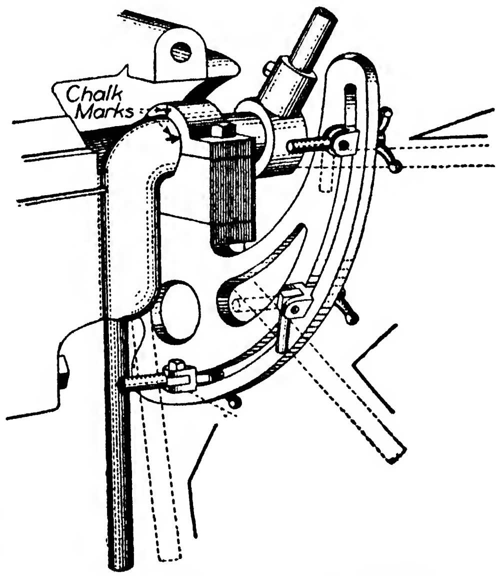


Fig. 45. View of Brake Showing Chalk Marks

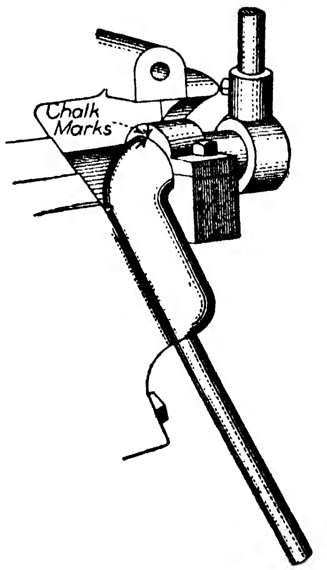


Fig. 46. Bending Leaf Raised until Chalk Marks Coincide

Occasionally on the completion of the forming of a bar (the curbs likewise) it will be seen that it has not been formed true to the profile, bend 2 being above 8 for instance, or perhaps these two bends will not touch each other as they should.

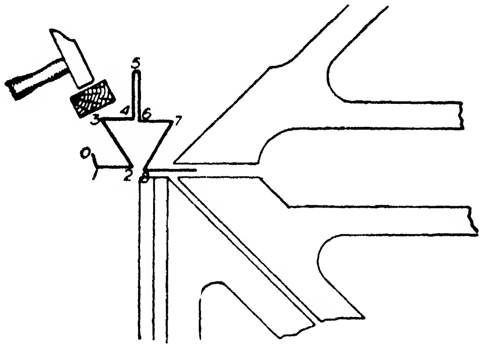


Fig. 47.

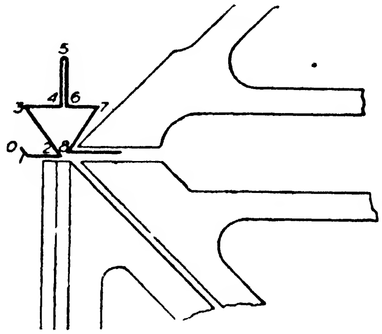


Fig. 48.

Remedying Bending Defects of Bar

In the first case, by inserting the high part in the brake and slightly raising the bending leaf, will remedy the defect. Inasmuch as it is customary either to tack the bar at intervals on the bends 2 and 8, or to slide on a bottom cap, the fault of the second case is not serious; still if it must be true to profile a good method is first to place one part then the other of the bar (8 9 10) in the brake, keeping bend 8 even with the outer edge of the bending leaf, and holding a smooth piece of wood, say 1 ft. long, on bend 3 and striking light blows with a mallet or hammer. This is time-consuming and consequently due care should be used in forming to have profiles true, and is mentioned here only because now and then a springy or heavier piece of material among the lot will upset all calculations. After doing this,

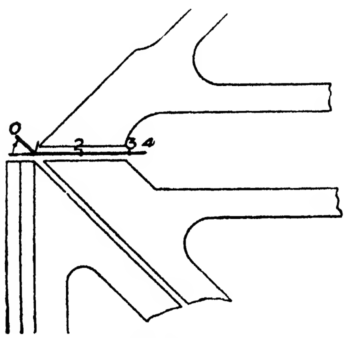


Fig. 49.

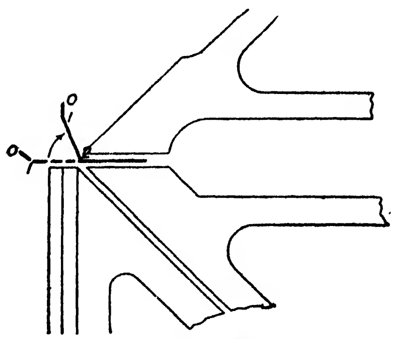


Fig. 50.

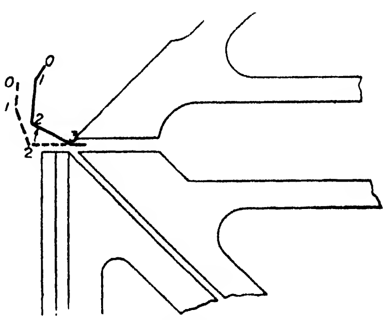


Fig. 51.

Operations for Bending the Caps

bends on 9 and 1 must be remade, they having been squeezed out by the clamp. And these two methods are shown by Figs. 47 and 48.

The operation for bending the cap D, Fig. 11, is quite simple; there being no turning of the blank, it is expected that Figs. 49, 50 and 51 will convey the procedure of forming. The cap E, Fig. 11, is bent similarly, excepting that bend on dot 2 is of a different angle.

Forming these profiles on the drop press differs so much that the bending of each profile will be explained separately, as was done for the hand brake operations.

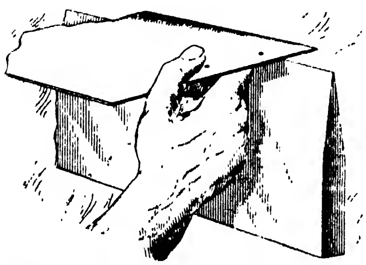


Fig. 52. Manner in which Sheet is Held

Pursuant to this, therefore, the bending of profile A of Fig. 11 is begun on dot 7, holding 6 to 0 in the hands as shown by Fig. 53. In all the other diagrams it is to be remembered that the part of the blank on the left hand side of the die (looking at the diagrams) is the part held by the hands, as shown by Fig. 52, which illustrates the right hand holding the blank. This bend is to be made to the smallest angle possible with the acute die, and as bend, dot 1, is the same way it will be necessary to turn the blank end for end, or turned around. Skilled brake hands usually make the bend of dot 7 on all the blanks, and as the bench used in conjunction with the power press is the swivel type, it is swung half way around, bringing the blanks in the correct position for bend on dot 1 as shown by Fig. 54.

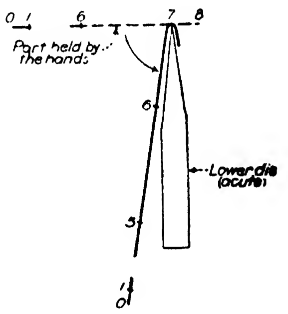


Fig. 53.

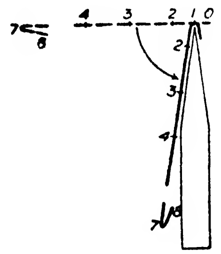


Fig. 54.

First Operations for Bending Lower Curb on Power Brake

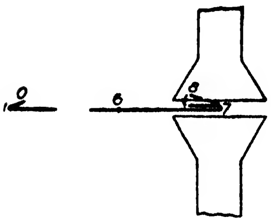


Fig. 55.

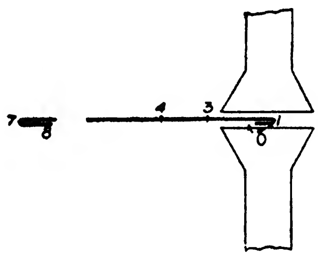


Fig. 56.

Flattening Hem Edges

The acute die is removed and the flattening dies slid into place and set so as not to close the bends too tight, when bend on dot 7 is closed as Fig. 55 and then dot 1 as Fig. 56, after which the blank is laid on the bench, care being taken not to let the blanks sag in the handling, as that would cause buckles to be formed in the hem edge. The acute die is again put in position in the press and adjusted to

make square bends, and bend on dot 2 made, Fig. 57. The blank is now pushed back of the die until dot 6 is in place and as it is somewhat difficult to steady the

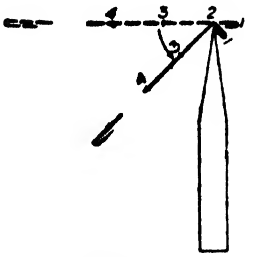


Fig. 57.

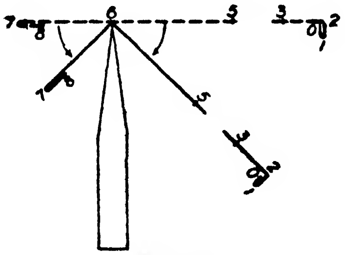


Fig. 58.

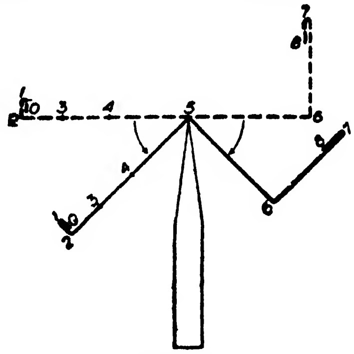


Fig. 59.

Continued Operation for Lower Curb

back owing to the excess of weight of the blank on the side not held by the hands, the upper die is caused to descend slowly, by working the treadle up and down, and when the upper die almost touches the blank, and when satisfied that the dot is correctly on the lower die, the die is caused to descend and ascend rapidly, Fig. 58. Turn the blank over and make bend on dot 5, Fig. 59, holding 0 1 2 3 in the hands. Turn blank over and bend dot 4, Fig. 60. With the partially completed blanks on the bench, it is swung half way around (some operators prefer to turn each blank separately) and make the bend on dot 3, Fig. 61. After running through all the blanks the die is set to make its smallest angle

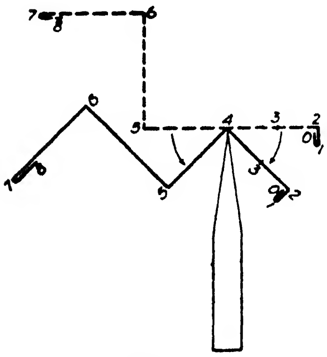


Fig. 60.

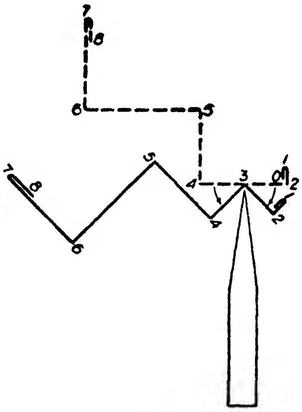


Fig. 61.

Two Bends of Lower Curb

and dot 5 is placed on the lower die and bend made to this small angle, Fig. 62. When this is done on all the blanks, the flattening dies are placed in the press and the bend on dot 5 is closed on Fig. 63, completing the forming of the lower curb.

To form the side and top curbs B, Fig. 11, the first operation is to bend dot 8 to capacity of die, Fig. 64, and this bend is now closed

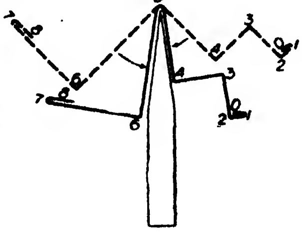


Fig. 62.

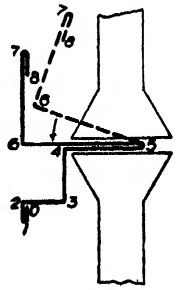


Fig. 63.

Final Operations for Lower Curb

as per Fig. 65. Acute dies are again placed in position and adjusted to bend square, and bend on dot 7 is made, Fig. 66. The blanks are turned around by swinging

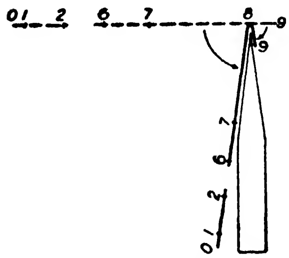


Fig. 64

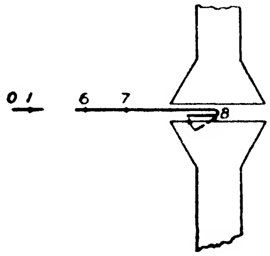


Fig. 65

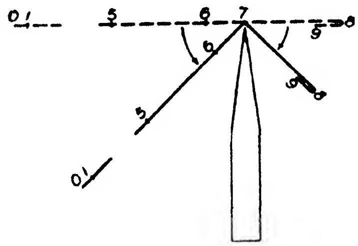


Fig. 66

First Operations for Side and Top Curbs

the bench half way around and bend on dot 6 made, Fig. 67. The blank is turned over and the bend on dot 5 made, Fig. 68. The blank is again turned over and

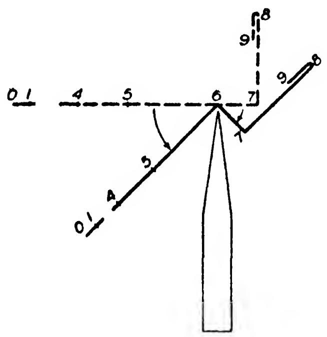


Fig. 67

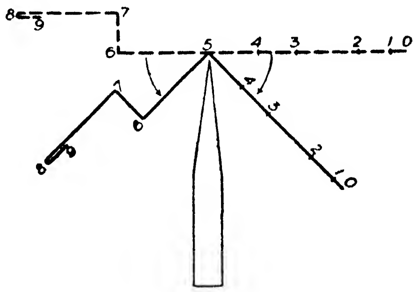


Fig. 68

Two Bends of Top and Side Curbs

the bend on dot 4 made, Fig. 69. Once more the blank is turned over and the bend on dot 3 made, Fig. 70. All the blanks should now be on the bench, which

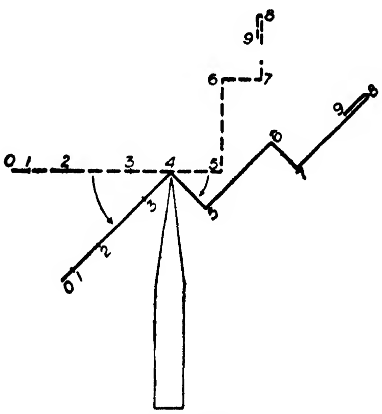


Fig. 69

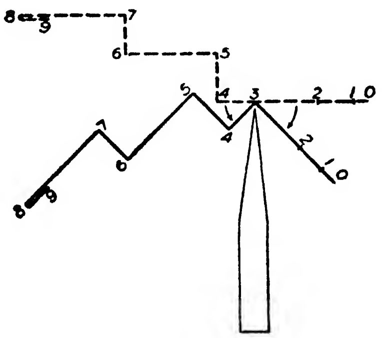


Fig. 70

Two More Bends of Top and Side Curbs

is swung around so that the blanks are end for end or turned around. The bend on dot 1 is made to the required angle, Fig. 71, and then bend on dot 2 to angle, Fig. 72. As the bend on dot 3 has been made square and not to the required angle, the blank is turned and the bend on dot 3 is made to angle, Fig. 73. To

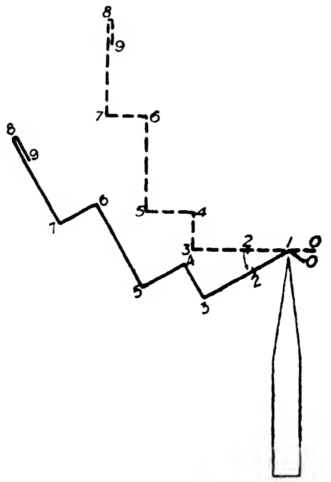


Fig. 71

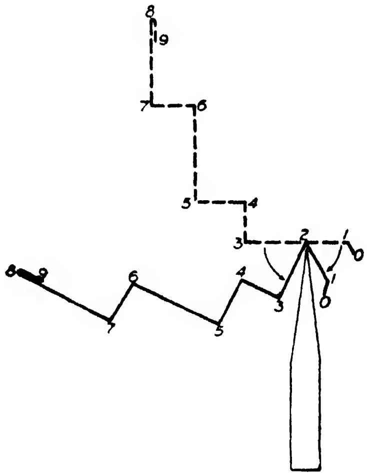


Fig. 72

Two More Bends of Side and Top Curbs

make this bend, it will probably be necessary to send the helper to the back of the machine to hold the blank, for at the front of the machine there is only the part

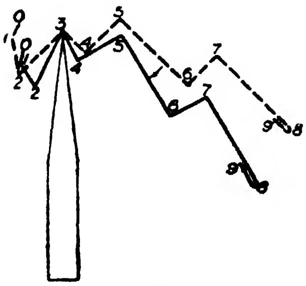


Fig. 73

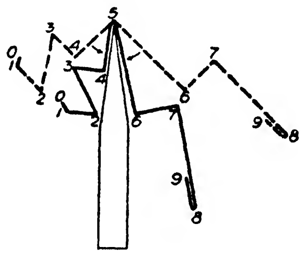


Fig. 74

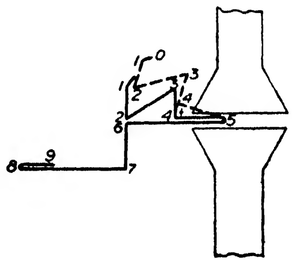


Fig. 75

Final Operations of Side and Top Curbs

from 0 to 3 to hold; this is permissible and is the customary procedure adopted by many rapid operators, for it saves considerable time and labor in turning blanks on the bench. For this reason, the back of the machine should be kept clear of all such stuff as dies and formed or unformed material; even the tackle used to change the dies should be hung to one side. The bend on dot 5 is brought to the smallest angle, as per Fig. 74. Flattening dies are now placed in position and the bend on dot 5 closed, Fig. 75, completing the forming of the side and top curbs. To remedy defects see Figs. 89 and 90.

The bar C, Fig. 11, is begun on dot 5 with 0 to 3 in the hands, and is bent square, Fig. 76. The blank is turned over and the dot on bend 6 made square, Fig. 77. The blank is drawn out and dot 4 bent square, Fig. 78. The blank is again turned over and the bend on dot 3 made square, Fig. 79. The blank is pulled out to dot 7, which is made square, Fig. 80. The blank is drawn out to dot 1, which is bent to the required angle, Fig. 81. All the blanks are turned around by swinging the bench halfway around and the

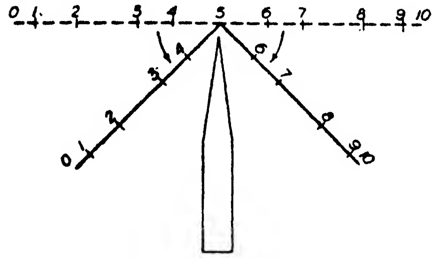


Fig. 76
First Bending Operation for the Bar

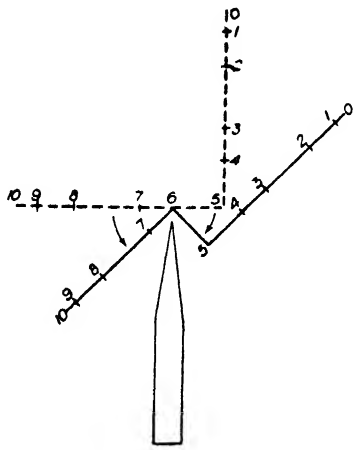


Fig. 77

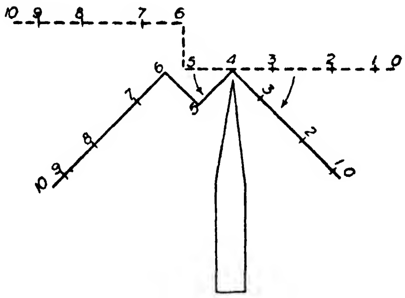


Fig. 78

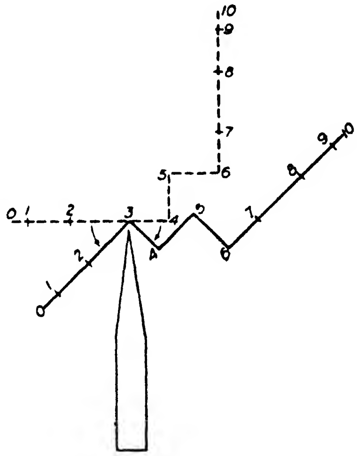


Fig. 79

Continued Operations for Bar

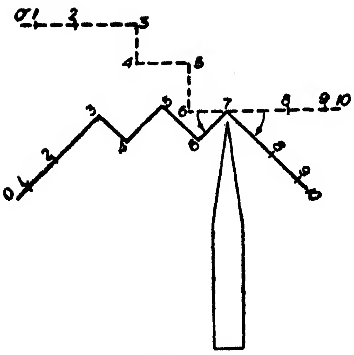


Fig. 80

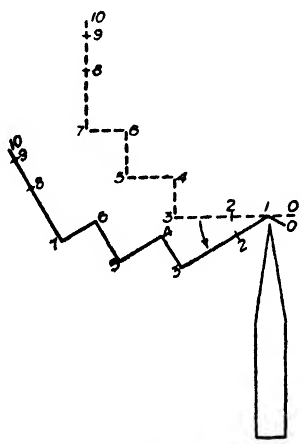


Fig. 81

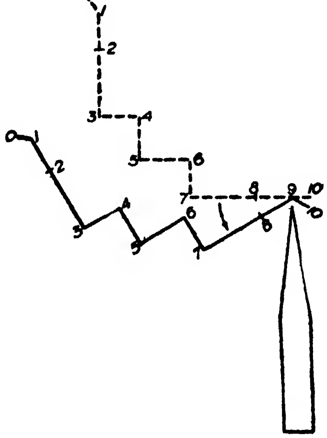


Fig. 82

Three Bends of the Bar

bend on dot 9 is made to the required angle, Fig. 82. The blank is pushed into dot 8, which is made to the required angle, Fig. 83. The blanks are again turned around by the bench and the bend on dot 2 made to the required angle, Fig. 84. The blank is turned over and the bend, which is now square, on dot 7, made to required angle, Fig. 85. The blank is pushed back and the square bend on dot 3 is made to the required angle, Fig. 86. The square bend on dot 5 is now bent to the capacity of the die, Fig. 87, and the flattening die placed in position and the bend on dot 5 closed, Fig. 88.

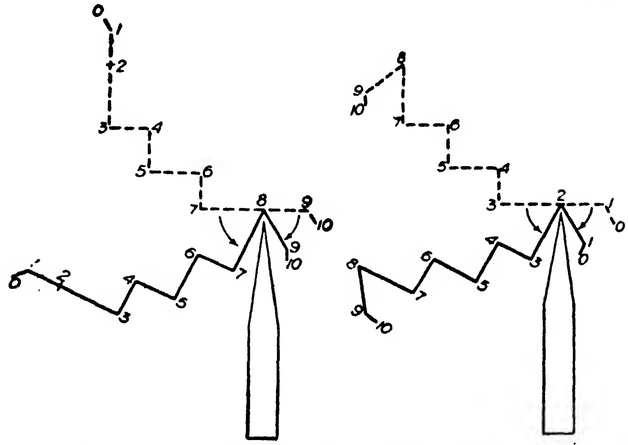


Fig. 83 Two More Bends of the Bar Fig. 84

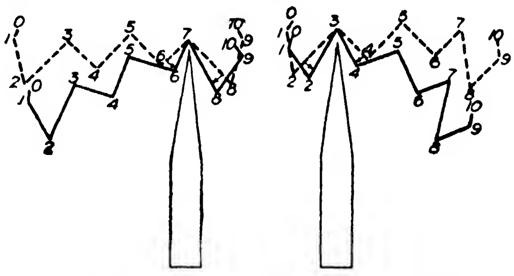


Fig. 85 Continued Bends of the Bar Fig. 86

Although this is not a dissertation in geometry it should not be irrelevant to point out that the bend on dot 7 is the same angle as the bend on dot 8 (or 3 is the same as 2); accordingly when the die is adjusted to bend to the angle of either dot, the adjustment will answer for the other dot. When forming up a number of blanks, however, it will be found that several will turn out imperfect. The reason why the bars are not true to profile is due more often to the material not being of uniform thickness, which causes the die to make bends of different angles, than to the fault of the operator. To illustrate, in Fig. 89, one of the sides has not been bent sufficiently to the angle and by raising the flattening dies and adjusting so that they will squeeze the side of the bar ever so little it will cause part A of the bar to travel towards part B, which is what is desired. If on the other hand the bar has too much bend on the angle of one side, as in Fig. 90, the flattening dies are brought down until they hold the vertical part or comb of the bar with the imperfect side up, and a hatchet stake or similar tool forced between

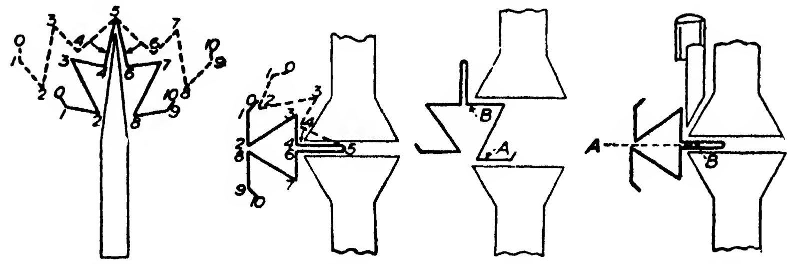


Fig. 87 Fig. 88 Fig. 89 Fig. 90
Final Operations and Remedying Defects of Bar

the die by pulling the shank of the stake outwardly, the bar will true up. Before doing this, a thin strip of steel is placed between the bar as indicated by line A B. This method of trueing up a bar, of course, is likely to pull the square bend out a little, which is of no moment. Naturally these methods apply to bars with both sides imperfect, and to the top, side and bottom curb. Although they may not remedy the imperfection absolutely, they will make the bars useable.

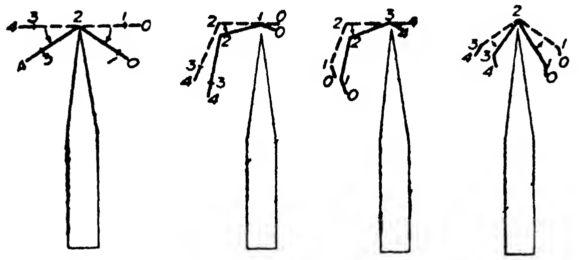


Fig. 91 Fig. 92 Fig. 93 Fig. 94
Complete Bending Operations for the Caps

The caps D, Fig. 11, are formed by bending dot 2 to the required angle, Fig. 91, and then bend on dot 1, Fig. 92. Blanks are turned around and dot 3 bent to angle, finishing the cap, Fig. 93. For cap E, Fig. 11, the bend on dot 2 can be either made as in Fig. 91, which is advisable, as it stiffens the blank for turning, and the other two bends made as in Fig. 92 and 93, and then the bend on dot 2 brought to the required angle, Fig. 94, or the bend on dot can be omitted and bends on dots 1 and 4 made as in Figs. 92 and 93, then the bend on dot 2 made as in Fig. 94.

The forming of the parts having been completed, the assembling is in order in this wise: Bars are first tacked with solder at 2 and 8, profile C, Fig. 11. These tacks are about 3 in. long and about 1 ft. from the top and bottom of the bar and about 1 ft. apart. Observing due care while doing this so that bars will not twist, and to assist in this precaution, the bars are placed bottom up between two straight strips of wood nailed to the benches indicated in Fig. 95. The copper cleats for holding the caps are now soldered on the bars and spaced according to the layout of Fig. 13. This can be most readily accomplished by nailing a strip of wood to the bench of the right hight. On this strip gauge marks are placed, for the cleats must coincide in spacing on all the work. The bar is laid on the bench with the strip of wood supporting the comb part and the cleats soldered on by holding the cleat with a pair of pliers and placing acid and a drop of solder on the cleat and bar and then

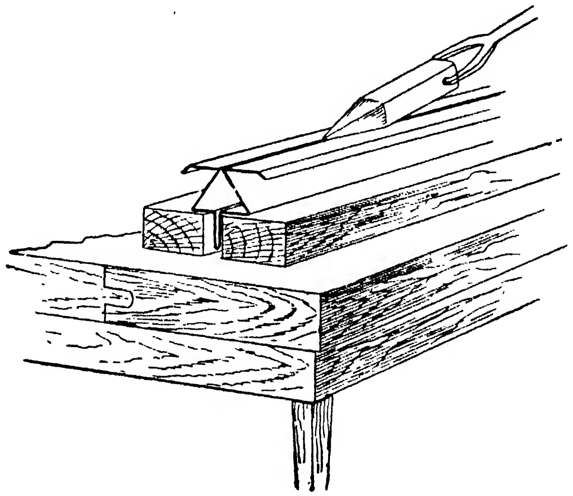


Fig. 95. Tacking the Bottom of the Bars

soldering by holding the hot copper on the cleat and drop of solder until the solder melts and flows all around and under the cleat, as illustrated by Fig. 96.

These cleats are as handy as any method known to hold caps. They are, nevertheless, treacherous and tear the hands of the workmen if left in a standing position, and are, therefore, turned down and again straightened prior to glazing. The foregoing explanations for soldering cleats and tacking the bottoms are relevant to the side curbs, and before laying these bars and curbs aside the laps are turned as required. This preliminary work obviates the need of interrupting the general assembling sequence.

There are no cleats to solder to the top and bottom curbs, but there is a seam to be made as indicated in Fig. 13. The two parts of the bottom curb are laid on the bench as shown in Fig. 97, lapping the seam the depth of the notches (shown by A in Fig. 12), for by doing this no further measuring of the curb is necessary. After going to the ends of the curb and sighting, and being positive both parts are in line both vertically and horizontally, the seam is strongly tacked on all the vertical and horizontal members of the curb, not forgetting to tack the apron part at the bottom, also at intervals along A. Holes are now punched and the seam riveted by placing the rivets on a thin iron plate which rests on the bench. The seam is then heavily soldered water tight, and while in the position of Fig. 97, condensation or weep holes are punched between the spacing dots for the bars, as indicated at B. It is to be understood that the riveting and soldering of the vertical members is done when the curb is in the position of Fig. 98, and that the seam of the upper curb is made in a like fashion, substituting the shape of the upper curb in place of the lower curb of Fig. 97 and 98, and remembering to tack 2 and 6 (profile B, Fig. 11). Following the idea of completing all preliminary work, before laying aside the upper and lower curbs, the laps are turned.

Before general assembling of the parts, a frame is made of stout timber conforming to the dimensions of the skylight, less ⅛ in. allowance for interference of laps and the like. When sure that this frame is square and straight it is securely nailed to the bench as shown in Fig. 99. With this frame in position a top and bottom curb are placed on it and kept from falling off by a piece of band iron bent and placed as shown by Fig. 100, one anchor at the center being sufficient. A side curb is now taken and placed on the frame, and while one man makes the miter to the bottom of the curb, another man makes the miter to the top of the curb, both men soldering the miters as much as possible. This repeated with the miters of the curbs on the other end of the skylight. The fire pot, acid, tools and the like are moved about on a small traveling bench built for this purpose. Ten bars

are now stood on end at the bottom curb and one man stations himself at the top curb, the other man at the bottom. The bottom man takes a bar and passes the right end to the upper man, who just prior to placing the bar in the correct position, turns down the small edge (1 to 0 of Fig. 11 B), for the bar passes over 1 2 of upper curb; both then placing it in correct position in respect to the center spacing dots for the bars on the curbs, and while a hammer held against the chest is pressed against the glass rest part of the curbs, the bar is soldered on the glass rest, that is along 2 3 of A and 4 3 of B, Fig. 11. The remainder of the bars are likewise soldered in place, working from this center one to the ends.

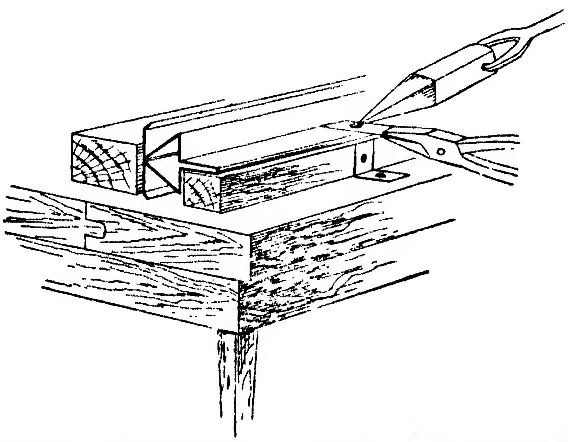


Fig. 96. Soldering Copper Cleats in Position, Showing Gauge Mark

As might be expected, this pushing with the chest and a hammer against the curbs is not relished by the men and quite often there is too much of a spring in the curbs and they cannot get the bars down as far as they should in the glass rests of the curbs, with the result that the glass is short, though otherwise it matters but little. The concern which has adopted this procedure for making skylights has a device with knurled grips which grasp the comb part of the bar. The tension of the grip is caused by link motion, which is actuated by a lever, working on a ratchet arc fastened to a block of steel that fits in the upright member of the lower curb under the glass rest; which receives the thrust, thereby bringing the bar and curb together. The ratchet maintaining the lever and grip at tension until the pawl on the lever is released from the ratchet.

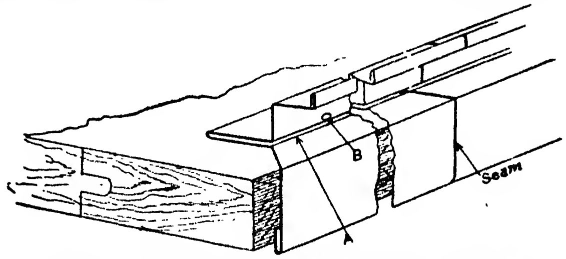


Fig. 97. Postion of Curbs for Making Seams

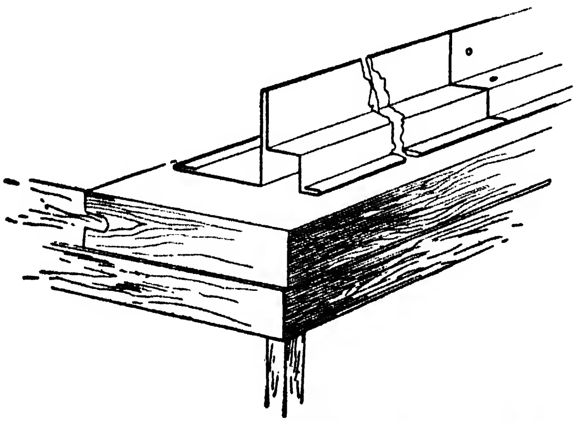


Fig. 98. Second Position of Curbs for Making Seams

When all of the bars are in place two men carefully lift the upper curb from the frame and push the skylight along the frame; then just before it is overbal-

anced they come to the front of the frame and stand the skylight on the floor on its lower curb. Letting the skylight rest in this upright position against the frame, the two men dress the laps of the bars to the lower curb with a dull chisel and hammer and solder the laps of the bars to the curb, that is along 3 4 of A, Fig. 11. They also solder laps of the miters of the curbs.

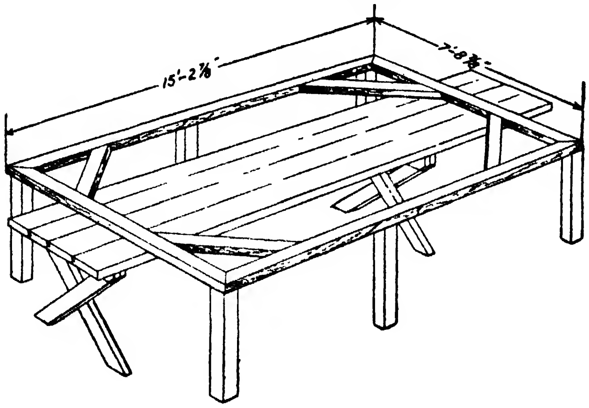


Fig. 99. Wood Frame for Assembling the Skylight

The skylight is again raised to the frame, slid to the other side and stood on the floor in an upright position on its upper curb, the laps dressed back and soldered on 5 to 4 and 3 to 2 of B, Fig. 11, as before. Once more, the skylight is lifted back to the frame, only this time bottom side up, and the miters finished, also the bars are soldered to the curbs at 1 to 0 for the upper curbs and 5 for the lower curb, Fig. 11, completing the shop work of the skylight, which is shipped to the job together with the glass, caps, etc.

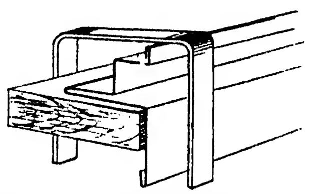


Fig. 100. Clamp to Hold Curb to Frame

HANDLING GLASS AND GLAZING SKYLIGHTS

As glazing skylights and hollow metal windows is part of the sheet metal worker's everyday occupation, it is of interest to explain how a large roofing contracting firm of Brooklyn, handles glass with a minimum percentage of breakage.

On the job in question not one light was broken, assuredly a phenomenal record. This job was a large pier. The roof was gravel and had 88 flat skylights about 8×16 ft., with 11 lights of glass about $16\frac{1}{2} \times 96$ in. placed in a double staggered row.

The working gang consisted of a non-working foreman, three mechanics and two laborers. The glass was packed with straw in crates, as is customary, averaging 22 lights to the crate. These crates were piled in a double tier at one end of the pier, as shown by Fig. 101. The first job, therefore, was to distribute the crates along the pier and nearly under the skylight openings in the roof. The object was to have glass piled on the roof in such a manner as not to have too much weight

on one spot and within easy walking distance of a certain number of skylights to be glazed and at the same time not to have too many shifts of the hoisting apparatus.

With a short pinch bar and a piece of wood as a fulcrum, one of the crates on

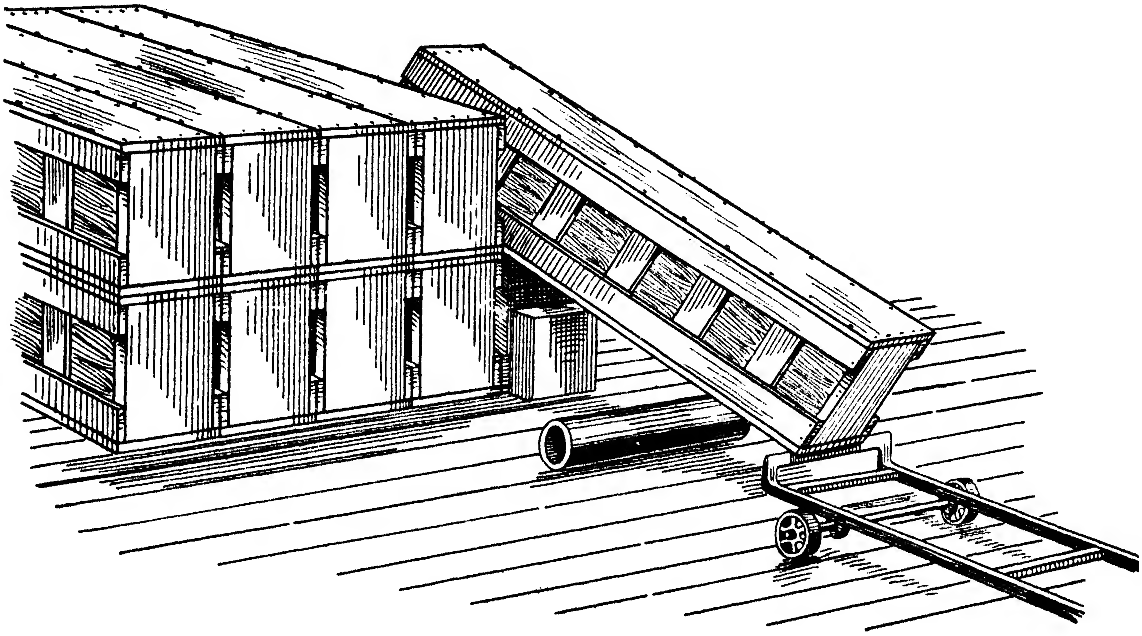


Fig. 101. The Tiers of Crates and Lowering a Crate from Upper Tier

the upper tier was raised sufficiently to put a piece of 2-in. pipe under it to serve as a roller. When the crate had been carried along on the roller far enough to balance on its edge, a block of wood one-half the hight of the crate was placed on

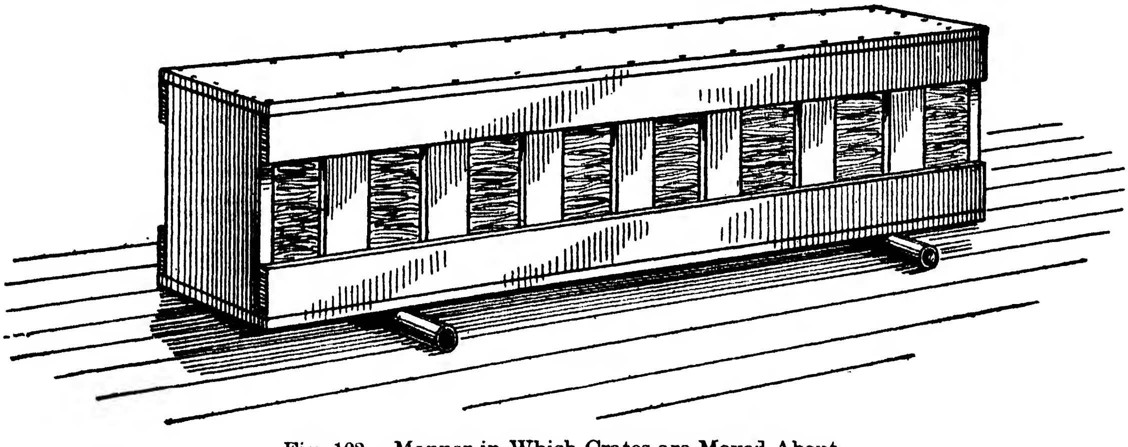


Fig. 102. Manner in Which Crates are Moved About

end against the end of the under crate. The upper crate was then carried along with one end resting on a longshoreman's hand truck and the other end allowed to drop on the block.

Experience has shown that it is not necessary to lift a crate bodily from a hight, but it can be dropped by easy stages without damaging the glass. Hence, in this case a block one-half the hight of the crate was used. The crate, however, must never be on its side. From this block the crate was allowed to fall on a roller. Then by means of these rollers, as in Fig. 102, it was pushed along the pier up a long plank and on to a hand car, which was operated on a railroad track running the length of the pier. When the crates had been carried on the car to the desired

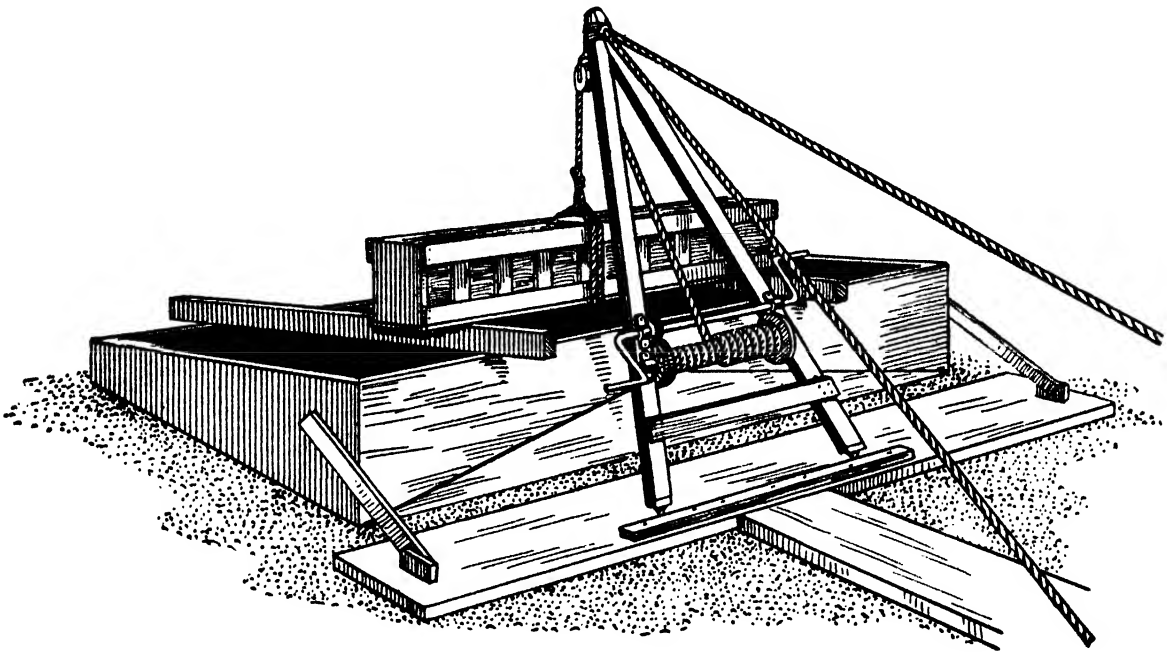


Fig. 103. The Derrick, Method of Securing it, and Landing a Crate

location they were dropped from the hand car in the same manner as they were dropped from the double tier.

To one unaccustomed to handling glass the terrific shocks these crates receive would cause him to believe the entire contents were smashed, inasmuch as a crate filled to capacity weighs several hundred pounds.

After distributing the crates along the pier the men went to the roof and rigged the hoisting apparatus. This was the ordinary cornice derrick. As roof was already graveled in, the derrick was erected on a heavy beam, so the sharp points in the legs would not dig holes in the roof. To prevent a backward movement of this beam, owing to the thrust of the derrick, it was lashed to the skylight curb, and also a long joist was nailed to the beam and run along the roof till it hit the roof curb, back of the derrick on the other side of the roof. This derrick of course

was placed on the high side of the roof curb, guyed and stayed in the usual manner, all as shown by Fig. 103.

The derrick was not sufficiently strong to raise a full crate. The glass was therefore, unpacked and repacked into crates which had been reinforced to stand the constant strain of rehoisting and especially lowering, when the crate was really thrown down. Eleven lights were sent up at a time, and while one crate was being unpacked on the roof another was being packed below. To keep the crate from

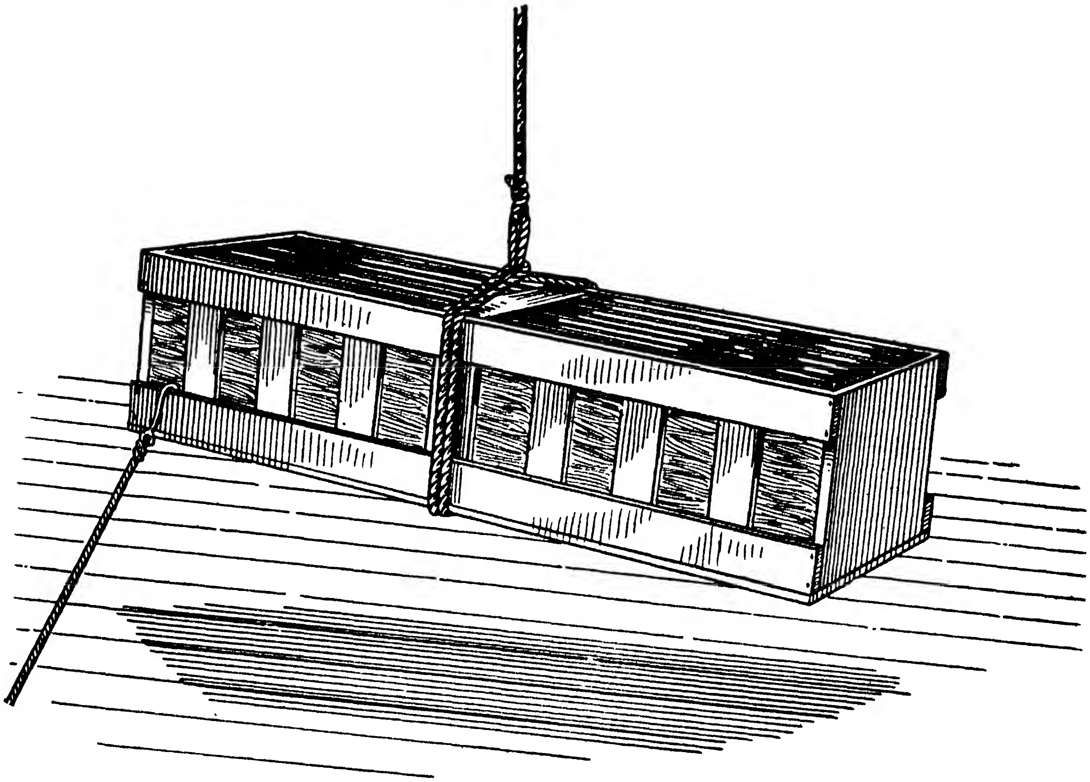


Fig. 104. Method of Packing Glass in a Reinforced Crate and Lashing it for Hoisting

revolving while being raised, a guy rope was hooked to one end of the crate and held by a man below. This procedure is portrayed by Fig. 104.

The hoisting rope was secured in the center of the crates with a sling allowing rapid unhitching, etc., though it required some thought and care to balance each crate. Of course, if it proved slightly unbalanced, it was steadied by hooking the guy rope at the end which had a tendency to rise.

As the bottom of the crate was a heavy board and as the top was removed, a stick was placed between the two sides of the sling to prevent it squeezing the glass. A few handfuls of straw steadied the glass in the crate, for the crates were but half filled by glass.

To land a crate on the roof it was hoisted a foot or so above the curb and the guy rope unhooked. Two pieces of heavy joist cut a few inches longer than the width of the skylight curb and with a cleat nailed to engage the lower part of the curb to keep the joist from sliding were then placed under each end of the crate.

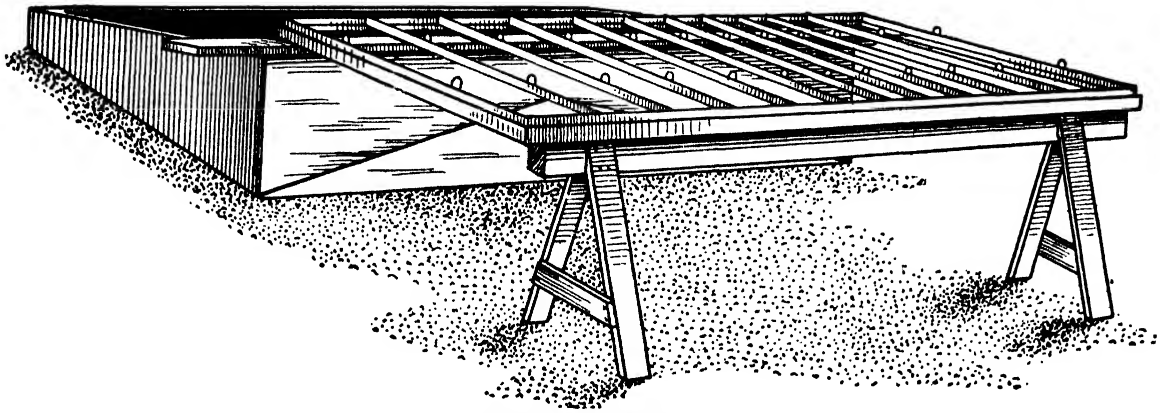


Fig. 105. **Heavy Wooden Horse for Supporting Skylight While Glazing**

The crate was lowered on these joists and slid along on them to the bottom of the roof curb. The sling was then unlashed, the glass unpacked and placed along the roof in empty crates when convenient, or the lights stood on their long edge against the roof curbs. To obviate danger of the wind blowing them down, bags of gravel were placed against them.

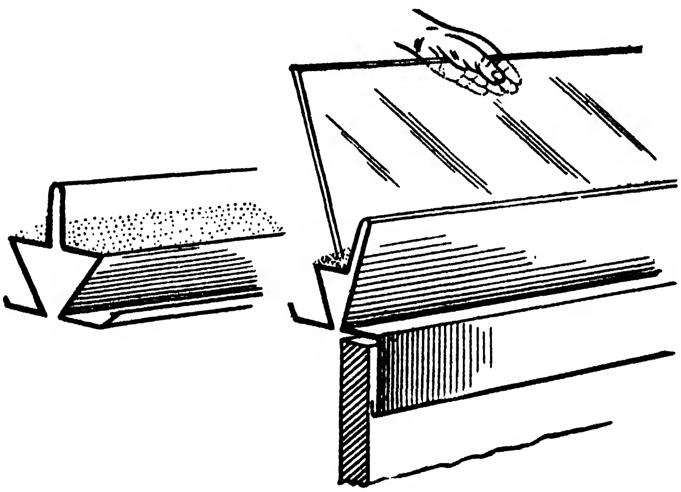


Fig. 106. **Manner in Which Glass is Laid in the Putty on the Bars**

The crate was now relashed, the straw and sling stick laid in, the crate raised from the joists which were removed from the roof curb and the crate was allowed to fall of its own weight, unwinding the drum of the derrick in its fall. From this it is not to be understood that the crate was allowed to strike the pier floor without retarding the speed of the fall as it neared the bottom, although a smashed crate would be of small consequence, for there were plenty of empty ones which were good for nothing more than firewood. To lessen the speed of the falling crate, a stout board passed between the drum and the crank axle of the derrick, acted as a brake, when the board was pressed on the drum using the crank axle as a fulcrum for leverage.

The method of glazing was to place a heavy beam along the top of the roof curb, the function of which was to prevent sagging of the skylight when sliding the skylight on to the roof curb. The lower part of the skylight was then placed on this beam and the upper part was supported at a hight that kept the skylight level, with a horse made of an inverted 15-ft. plank that had legs at both ends

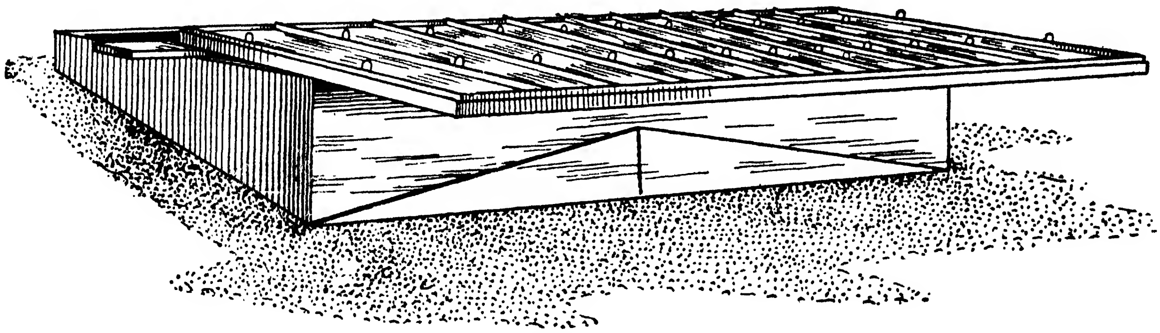


Fig. 107. Sliding the Skylight on to the Roof Curb

made of heavy boards as illustrated by Fig. 105. It might be said that as the roof had but a slight pitch the roof curbs were constructed with an additional pitch, as can be seen in the illustrations.

After placing the skylights on the curb and the horse, one man straightened out the copper cleats, looked over the skylights for possible breaks or defects and then puttied the bars. The two laborers carried the glass and two mechanics laid the glass in as shown by Fig. 106, working from one end to the other of skylight. After pressing each light of glass into the putty, using considerable pressure, they cleaned the surplus putty from the top and bottom of the bars. This surplus putty was used on succeeding lights.

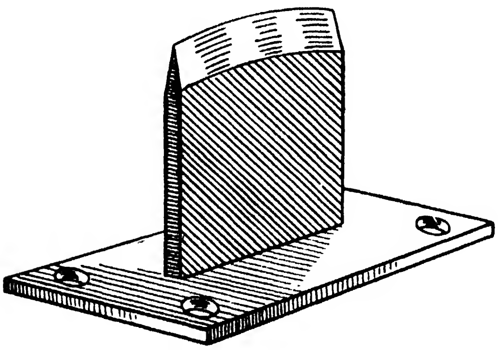


Fig. 108. Cap Punching Knife

The skylight was now slid on to the roof curb by two men holding the beam and causing it to move along the roof curb and the other three men holding back of the skylight curb as shown by Fig. 107. When the skylight was in place the upper three men came to the bottom and raised the lower part of the skylight just enough to allow the two men holding beam to remove it. These three men now lowered the end of skylight they were holding. During this sliding on of the skylight on to the curb extreme care was exercised not to rake skylight, as that would disturb the set of the putty and perhaps break some glass.

The copper cleats to hold the glass were soldered on the bars at a fixed distance, so when punching the caps it was only necessary to have a gauge and punch all caps alike and to this gauge. The chisel and hammer were not quick enough for one of the mechanics, so he devised a scheme of inverted chisel-like knives, Fig.

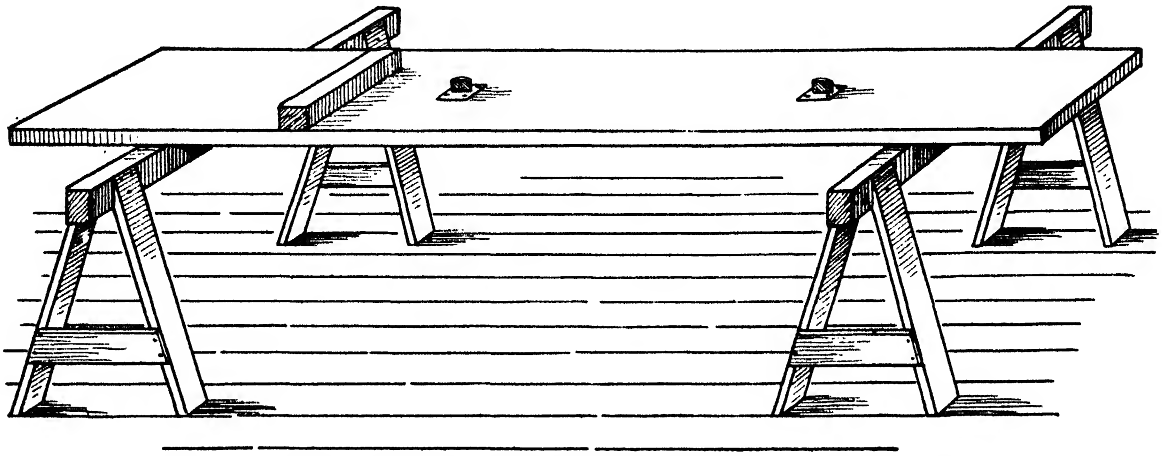


Fig. 109. Bench to Which Punching Knives are Secured. Also Gauge Block

108, slightly wider than the copper cleats, and nailed them to a plank, Fig. 109, at a distance and in such a manner that when the cap was placed on these knives and struck with a mallet the cut would coincide in distance apart and from the ends with the copper cleats on the bars.

Caps were now put on the skylight bars and the protruding part of cleats folded over the caps and dressed down to hold the caps snugly to the glass. Inexperienced men always break considerable glass doing this. The caps were then soldered to the upper curb caps, which in turn were soldered to upper skylight curb. The skylights were then securely fastened to the roof curbs with wood screws through the apron of the skylight curbs—three screws on the sides and six at the top and bottom.

RIBS OF GLASS IN OR OUTSIDE IN GLAZING SKYLIGHTS

There being a diversity of opinion in the trade, relative to which side of the glass should be placed outside, the following from an experienced contractor of sheet metal work and roofing, is of value, and who writes as follows: Answering the inquiry in reference to which side of the ribbed skylight glass should be placed on the outside, I beg to state that I think the ribbed side should be placed uppermost. When an apprentice I was told that the glass was made with the ribbed sur-

face so that the ribs would keep the water from spreading underneath the caps and getting down into the gutters of the skylight. I do not think that the ribs have any value as diffusers of light, and in reference to this I beg to quote the recognized inventor of the sheet metal skylight, who states: "We always advise rough plate glass in preference to fluted; it will admit more light, while it is equally translucent. It is a mistake that the flutes act as prisms, and that they diffuse the light to a greater degree than the rough plate. In our experiments as to the quality of light admitted the result was in favor of the rough plate. The experiment consisted of photographing each piece suspended in space. By this means the degree of translucency by shadow and light is determined."

It is my opinion that if the ribs were intended as diffusers of light they would extend *across* the glass instead of with it. Some manufacturers have the glass placed in the skylights with the ribbed side down, claiming that the ribs gather the dirt unless this is done. It would seem more reasonable to put the smooth side down, as this will allow the condensation a better chance to follow the glass down to the gutters without dropping off same than if the ribs were on the underside.

Any one who doubts this can prove the assertion by wetting one side of the glass and allowing the water to run off while the glass is placed flat, with one end on a bench or table and the other end slightly elevated. It will be found that the water spreads over a considerable surface of the glass and runs down to the bottom without dropping off. By turning this glass up until the water runs to one edge of same it will be found that the water is much more liable to drop off the sharp edge of the glass than it would off the wide flat surface. This edge may be compared to the rib of the skylight glass.

BUILT-IN FLAT SKYLIGHTS

One of the serious faults with the conventional type of flat skylight, which is set on a raised curb, is that it acts as a dam to the flow of water of that portion of the roof back of the skylight, for this flow must be diverted to the sides of the roof curb of the skylight. The greater the length of the skylight the more serious is this fault, and it is history that many skylights have leaked owing to the snow or ice and water banking behind the skylight and overflowing between the roof curb and the apron of skylight curb.

A form of construction which allows the water to run uninterruptedly to the eaves of the roof, and one which can be built, by reason of this, continuously the

entire length of the roof, is shown in Fig. 110 and is known as a "built-in" type. The type of roof is the ordinary inclined timber roof of wood trusses; the top chord supports heavy purlins, to which are framed the roof rafters that are set at right angles to the eaves. As is customary, the top and lower curbs of the skylight are directly over the purlins, the spacing of which governs the length of the span of the skylight.

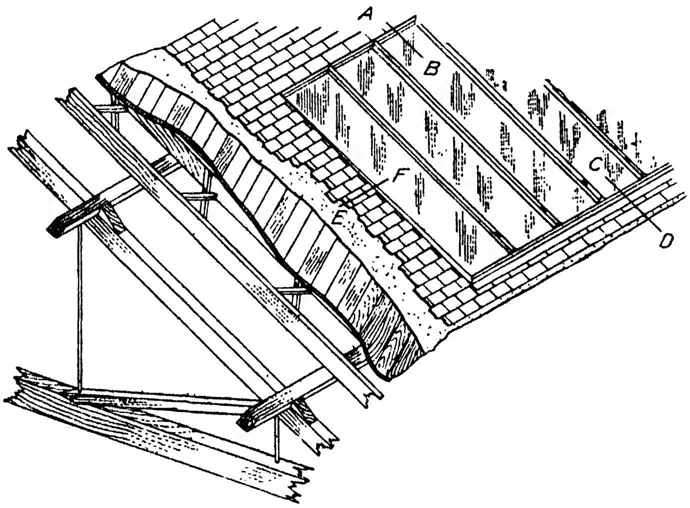


Fig. 110. Perspective View Showing Constructive Details

In Fig. 111 is shown a section of the lower curb (on the line C D of Fig. 110). As will be seen, a roof rafter is set flush with the upper edge of the purlin, the lower rafters of the roof finishing against this rafter. On top of all the usual 7/8 sheathing boards are nailed, diagonally. This applies to the upper curb, excepting that the rafter is set flush with the lower edge of the purlin, and for the side curbs the regular roof rafter is the means of support, making in all a sunk roof curb instead of the raised in the general style of skylight.

The lower curb of the skylight has formed integral to it a pocket, into which is inserted the last two courses of slate, these slates being laid on roofing felt or building paper, which should continue under the metal curb. A metal cap, which is just tacked at intervals to the pockets, covers the nails of the slate. As a precaution it is well to fill the pocket with elastic cement (paintskins) before covering with the cap. As shown in Fig. 111 this pocket raises the curb. Therefore, a furring strip is first nailed to roof sheathing to carry the weight of the curb.

To prevent sliding of the glass a little edge is bent up, as indicated at *a*, with the additional strengthening hem edge, which also precludes the rusting that occurs when a raw edge of galvanized iron is left exposed. The thrust of the bars and glass is balanced by the bent part of the metal curb at *b*; and although it may seem an assertion open to debate, it is, nevertheless, true that wind pressure is more to be reckoned with under a skylight than above, or the outside, especially as skylights are set long before the complete closing in of the building; for safety, then, from this under-pressure of the wind, the metal curb is nailed (wood screws, perhaps, would be best) at *b*, and a screw placed as shown as *c*.

Recent experiments by engineers of authority have brought to light some interesting facts relative to the phenomena displayed in connection with skylights and roofing material blown from the lee side roofs of buildings that had no openings to allow wind to enter and create pressure under the roof. From the tests and observations it was gleaned that the wind sliding, as it were, up the windward side of the roof, passed some distance over the lee side of the roof, bringing about a partial vacuum, or rather, a positive suction over that area. This force was of sufficient power, it was determined, to raise heavy skylights and the like, even though they were fastened to the roof proper.

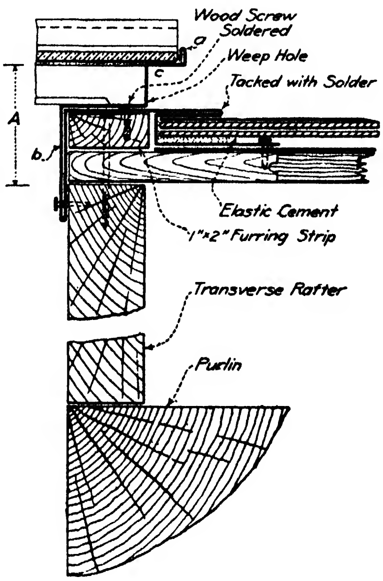


Fig. 111. Details of Bottom Curb

The sections (or profiles) of the side curbs and bars are shown by Fig. 112, and is a section on the E F of Fig. 110. The bar is of the universal type and may be reinforced by a core plate and bottom cap for excessive spans. The side curbs consist of a half section of the bar and a straight side, the comb of the bar of the curb being doubled on itself to form a pocket *b*, into which is slid the cap *a* after glazing. The side curb is bent out on the roof about 8 inches with an edge turned up to attach cleats to hold it to the roof; this edge is often intended to act as a guard against any water which may seep under the slate, it being assumed that this edge will convey the water down to the apron (or cap) of the lower curb and thence over the slates. That it will do this is extremely doubtful, inasmuch as the weight of the slate and many other causes will crush this edge so tight that it will not be efficacious for the purpose outlined. Hence, it is the common practice to bed the slates in elastic cement at this junction.

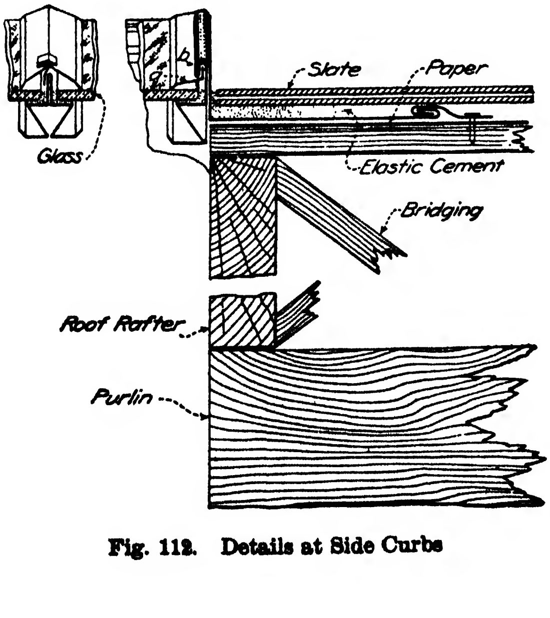


Fig. 112. Details at Side Curbs

The top curb, Fig. 113, which is a section on line A B, Fig. 110, is formed to coincide with the general dimensions of the bar and side curb with the modifications shown, to allow nailing at *a*, and the cap *b* to cover the glass. A roof

flange extends up the roof for, say, 6 to 8 in. and is nailed. A cant strip (ordinary plaster lath) is suspended by strips of sheet metal at intervals of about 1 ft., which are nailed to the roof above the flange of the curb. Over all of this the slates are laid as if they were for the eaves.

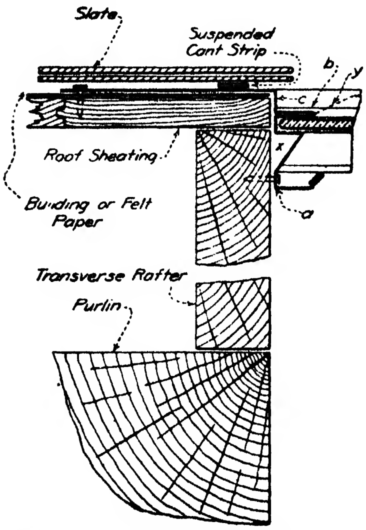


Fig. 113. Details at Top Curb

To facilitate assembling, the comb of the bars is cut off on a sufficient slant to pass the cap of the upper curb, as shown by the dotted lines X Y. This in no wise affects the strength of the bar. The cap of the bar is soldered water tight to the upper curb at *c*. This type of curb has never been known to leak, and condensation will flow away from it. Still, it is well to make the curb at *a* fairly large to catch and retain until evaporation any stray drops of water that may find their way there.

The general scheme of erection is to set the entire skylight and then lay the slate, after which skylight is glazed. The men usually work from a scaffold hung below the skylights, which allows access for cleaning surplus putty from under the glass after the skylight has been capped. The capping is accomplished on scaffolding built up from the eaves or suspended from the ridge.

Should the span of the skylight be such as to require glass in two lengths, necessitating a cross clip, two methods are suggested. One, the details of which are delineated in Fig. 114, has always proved unsatisfactory owing to the frequent leaks ascribed to them, even though they are the cheapest and quickest means of supplying a junction for the two lengths of glass.

Where cost is not paramount to efficiency, terracing is the best method to employ. The advantages are many, chief of which is positive impervi-

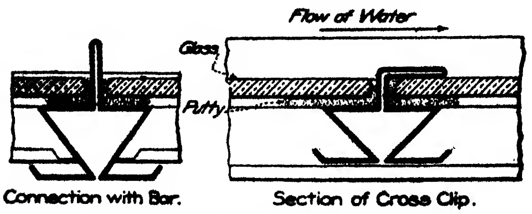


Fig. 114. Details of Cross Clip

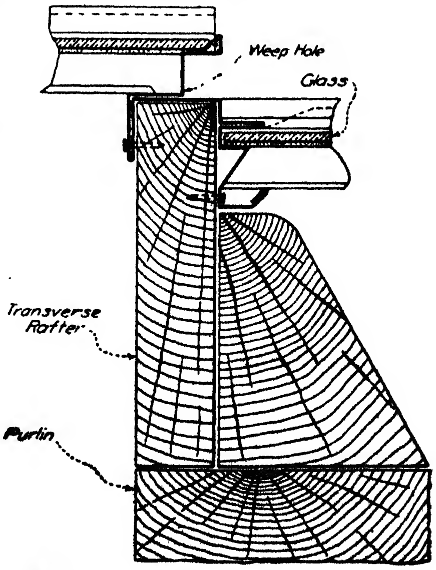


Fig. 115. Details of a Terrace Curb

ousness to the elements and additional provision for directing the condensation to the outside. Presuming that the spacing of the purlins is such that a light of glass will span from the center of one to another, Fig. 115 shows a form of terrace curb that, with suitable changes to meet requirements of the job at hand, has not been found defective under trying conditions. As a suggestion it is said that this curb could be made in two parts, in case in the assembling scheme it is contemplated to erect each terrace section successively. The terrace sections could then be made in easily handled lengths, as described in the next article.

From an inspection of Fig. 110 it will be seen that the rise of the lower curb above the upper curb must be allowed for when designing this type of skylight. As this slant varies for the different spans, inasmuch as the rise of A, Fig. 111, remains the same, no attention was paid to this when drawing the sections, for the slant of any span taken as an example would be imperceptible in diagrams so small as these.

A NOVEL METHOD OF BUILDING A DOUBLE PITCH SKYLIGHT WITH GABLE ENDS

This article will tell how a young man who had just gone into business for himself, having previously been employed as foreman for a cornice concern, secured the contract for a double pitched galvanized iron skylight 10 feet 2 inches by 96 feet 2 inches, to be glazed with 3-16-inch ribbed glass in lights about 18 inches in width. The ends of the skylight were to be finished in wood gables. Having no details or patterns it was necessary to make some, the principles of which are so elementary as to require no elucidation here, inasmuch as design was the essential for work of this nature. He, therefore, designed the sections, as follows:

Fig. 116 shows a section through the eave curb A, ridge B and interior zinc gutter C, which the owner of the building insisted upon using to provide for the possible freezing up of the condensation outlet tubes D. Fig. 117 shows a section through the gable curb E and bars F. Fig. 118 is a broken plan view of the complete skylight showing general dimensions, bar spacing and location of joints in curbs and ridge, as related to the location of the bars on each side of the joints, which were calculated to come between two bars.

By making ridge, B, in two parts, as shown, each slope of the skylight could be made in 8-foot sections and then carried to the building and assembled or

erected in place. The extent of the young man's facilities was an 8-foot wood brake, hammer, snips and soldering kit. He was, therefore, obliged, after laying out his patterns, to cut out all of the work by hand.

Altogether, 126 bars were necessary, which required blanks about 65 inches long. The girth of the bars was 7½ inches. He therefore cut 33 sheets of No. 26 96×30-inch iron down to 65 inches; then he pricked off two 30-inch strips into four equal parts and transferred the prick marks to the ends of the 65-inch sheets, so that a straight edge could be used for marking off the blanks. After cutting the blanks he cut the pattern of one bar full length with miters, and while his helper worked at cutting out the other bars from this pattern he cut out the curbs and ridge and also the gable curbs and the zinc gutters.

When the work was all cut and formed complete he constructed a frame or form, shown in Figs. 119 and 120, from which to assemble the work in 8-foot sections. Fig. 120 is an end view of Fig. 119. The frame was constructed of 1×3-inch wood strips with galvanized iron forms, *a* and *b*, secured to the longitudinal side strips. The profile of form *a* conformed to that of the curb, and the profile of *b* conformed to that of the ridge. The dotted lines, Fig. 120, show a section of the skylight in position on the form.

The form was supported on trestles, so that the operator could stand erect at his work. In using the form it was only necessary to lay the sections of the curb and ridge in place and secure the bars in proper position between them. The position of the first bar was determined by dimensions taken from Fig. 118, showing the distances of the bars from the joints of the curb and ridge. The spacing of the other bars in each section was determined by two 1×3-inch wood strips, fashioned as shown by Fig. 121, having notches sawed into their edges about 1½ inches deep and 18 inches apart, the notches having been sawed while the strips were secured together. In spacing the bars one strip was placed near the curb and the other near the ridge, so it was only necessary to measure for the location of the first bar in each section and the wood spacing strips took care of the spacing of all the other bars.

The condensation outlet tubes D, Fig. 116, were not put in until after the skylight was assembled in 8-foot sections. The glass was ordered cut to size and shipped direct to the building. In erecting the skylight the forward ends of each 8-foot section of the metal curb were securely nailed to the wood curb. The inch laps, which were, of course, allowed on the curb, covered these nails, and in addition to this nailing the metal curb was secured to the wood curb by brass screws, *a*, Fig. 116, placed about 1 foot apart and the heads soldered over.

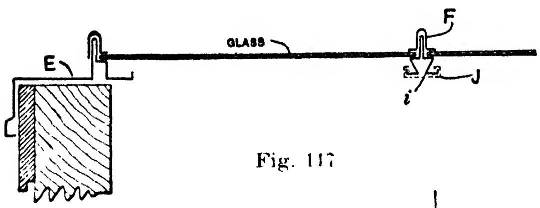


Fig. 117

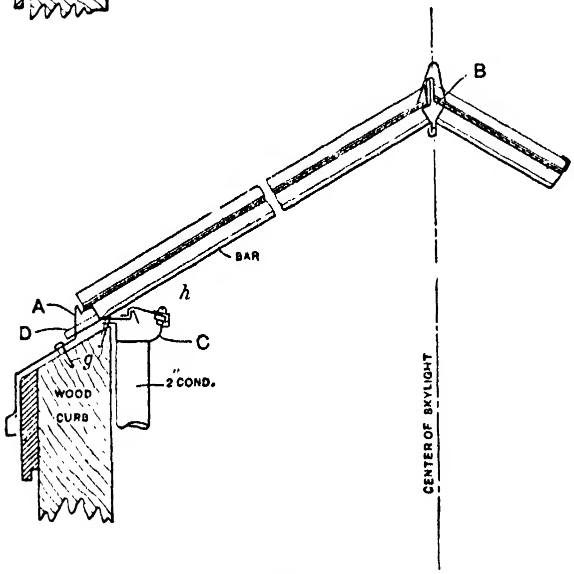


Fig. 116

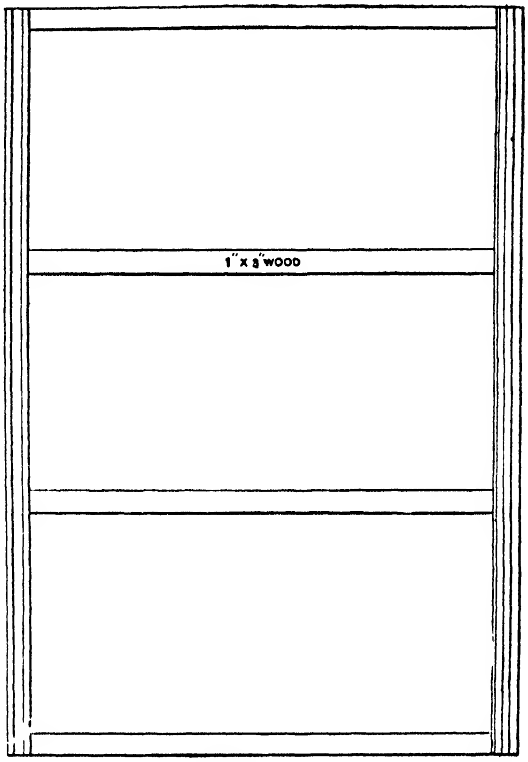


Fig. 119

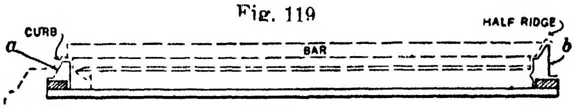


Fig. 120

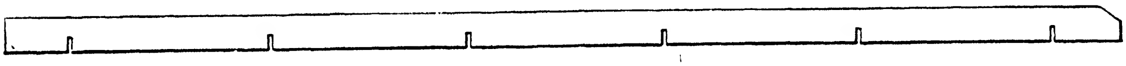


Fig 121

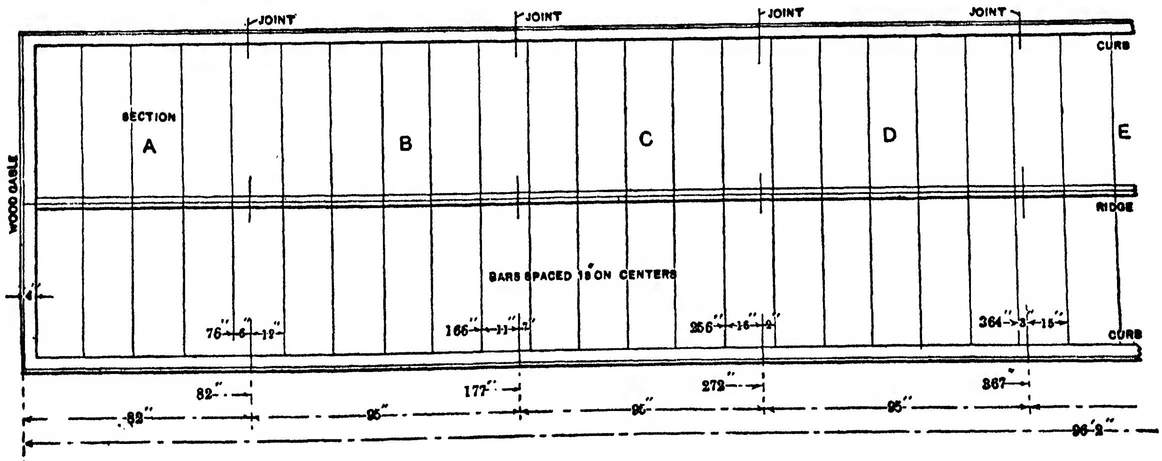


Fig. 118

Drawings to Show a Novel Method of Building a Skylight

It was, of course, necessary to put up the zinc gutter C before placing curb A in position. The inner edge of the zinc gutter was supported by straps, *h*, bolted to the zinc gutter and passed upward over into and soldered in the gutter of curb A. The zinc gutter was drained by 2-inch conductors, running downward into and through the building alongside of the supporting columns and emptying into drains underneath the floor. The bars F were soldered solid throughout their entire length at the point *i* in order to take care of any condensation which might form inside of the hollow bar and drip off into the building instead of following down into the curb gutter. It would have been better if a gutter cap, J, had been provided, as this would not only take care of the condensation, but would allow of a certain twisting flexibility of the bars in assembling, whereas if the bars should be slightly twisted when soldered along the line *i* they would remain rigidly twisted and result in an uneven surface for the glass to rest on.

Ordinarily such a skylight would have been knocked down in the shop and put together complete on its curb at the building, but by carefully figuring out the exact locations of the joints in the curbs and ridge as related to the location of the bars on each side of the joints and by the use of the wood form and the wood spacing strips and by making the ridge in two parts it is much quicker, as well as more accurate, to assemble the work in sections in the shop where everything is convenient and comfortable in cold weather, leaving the minimum of work to be done on the outside.

CONSTRUCTION OF METALLIC EXTENSION SKYLIGHTS

In this article it will be endeavored to explain some of the current methods employed in the construction of extension skylights, such as are used in buildings of the present day, giving particular attention to methods of obtaining water tight joints between the wall and girders and skylight. In Fig. 122 is shown a general view of an extension skylight, in which A indicates the joining of the upper frame of the skylight against the wall, B B B the flashing between the wall and skylight, C the step flashing, D the joining of side bar and wall, E the joint between lower frame of skylight and gutter, F the condensation tubes, G the ventilator and X X the cross bars required when glass must be used in two or more lengths.

In Fig. 123 is shown a cross section taken on the line J K of Fig. 122. In Fig. 123, A shows the iron girders and B the galvanized iron frame resting on the flange of the beam. C shows the brick wall at the bottom, on to which the gutter

D is hung and the lower frame E soldered to it. In some cases no hanging gutter is employed, but a cast iron gutter is set directly on to the wall, as shown at F.

In Fig. 124 is indicated a constructive section showing the method of fastening the upper part of skylight to the iron girder. A represents the iron girder or

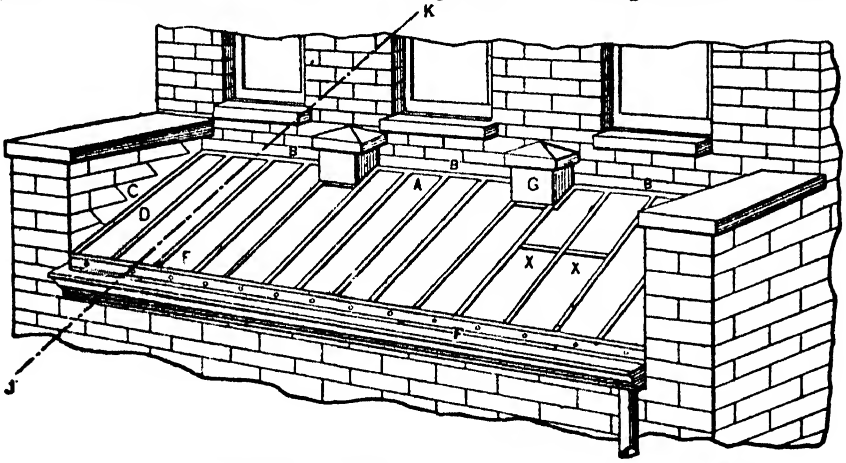


Fig. 122. Perspective View of a Finished Extension Skylight

beam, B the brick wall built on to it. C shows the shape of the upper part of frame, formed in such a way that the lock or joint comes at D. The entire length of the frame C is now blocked out with spruce, as shown at E. The shape of the opening being obtained, spruce strips are cut at the planing mill by the wood worker, slipped into the galvanized iron shape and fastened with a few roofing nails, which hold it in place. F represents a section of the skylight bar, formed in such a way that the joint occurs at J, and is riveted to the core piece H, as shown. The size of the core bars should be regulated according to the size of the skylight. While for a skylight having a span of 8 ft. bars $2 \times \frac{1}{4}$ in. would be required, on a skylight of larger span T-iron would be required. To find the safe uniformly distributed load that the core bars will carry, consult any engineers' book, furnished by rolling mills free of charge. When finding the safe load, take into consideration the span of the skylight, the distance the glass is placed in lights, the thickness of the glass and the exposure presented to catch snow, sleet and ice.

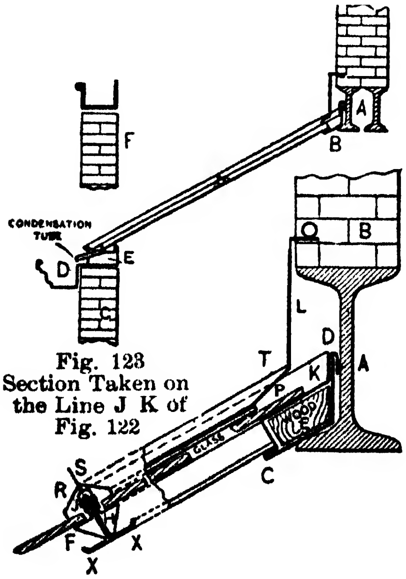


Fig. 123 Section Taken on the Line J K of Fig. 122

Fig. 124. Method of Fastening Upper Part of Skylight to Iron Girder

The bar or rafter is now mitered against the upper frame E, the flange C being placed to hide the seam between the rafter X X and the frame.

The glass is then laid in putty, allowing it to rest on the upper frame as far as shown by K. The glass being placed in position, a combination flashing and cap is placed over the glass, as shown at L, flanging it into the joint of the brick work at O, fastening with wall hooks and paintskin. When doing this work the glass, of course, is all in place; a number of boards are laid across the rafters to avoid the breakage of glass when working. When the upper flashing is in place caps are placed over the bars, as shown at R, and are fastened by means of the copper strip ½ inch wide riveted to the bar by the rivet J, passing through a slit cut with a chisel into the cap R, as shown by the copper strip S, which is then hammered over the cap. Where the cap R butts against the upper flashing at T it is mitered and soldered to fit against the flashing at P. In this manner the upper part of the frame is made water tight against the iron girder A and wall B.

The method of bending the frame and bar in an ordinary cornice brake as now employed is shown in Fig. 125 of the illustrations. In order to bend the frame shown by C D of the previous figure commence at A of Fig. 125, turning it over as far as possible; then make the bends at the required angles, as shown by B C D. At E turn the bend again as far as possible and make the bend F as required. Now place the bend E in the brake and close, and the result will be shown by E^1 in diagram M. Close the bend A^1, which will complete the frame ready to receive the wood blocking. When bending the bar or rafter, shown by H in Fig. 124, start at the bend 1, diagram N, of Fig. 125, and make the bends 1, 2 and 3 according to the profile of the bar; bend 4 as far as the brake will bend it; likewise bend 5 in the same manner. Make the bends 6, 7, 8 and 9 according to the profile of the bar. Place the bend 4 in diagram N into the jaws of the brake, close, and the result will be as shown at 4 in diagram O. Turn over the bend 10 in diagram O, as shown at 10, 11. Now place the bend 5 in diagram O in the brake, close tight, and the result will be as shown at 5 in diagram P. At X and X in diagram P make slight bends, which will form the condensation gutters beneath bar, as shown by X X in Fig. 124. The bar being completed as far as shown in diagram P in Fig. 125, the iron core is now passed in the bar and riveted, as shown by J in Fig. 124. There are, however, large presses to form bars in two operations, but the expense of these machines keeps them from all except large skylight manufacturers.

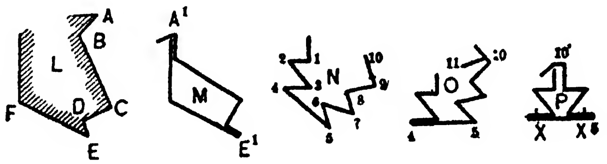


Fig. 125. Method of Bending Upper Frame and Skylight Bar

In Fig. 126 is shown the method of fastening the lower part of skylight frame to cast iron gutter. A represents the brick wall and B the cast iron gutter furnished by the iron contractor. C D F shows the shape of the lower frame, formed of sheet metal and riveted together at D; the bar E miters against the base, as shown, and is riveted to the base at F. To make a finish on the inside a wooden molding, H, is placed in the opening between the cast iron gutter and the flange F. Should there be any condensation it would follow the gutter under the bars at E and drip into the gutter of the base at J, and then to the outside gutter by means of the condensation tubes C. The condensation gutter of the bar is cut as shown at K so as to allow the water to drip into the gutter.

Sometimes, instead of placing a molding at H of wood, the molding is cast direct on to the cast iron gutter, the measure of which must first be taken before

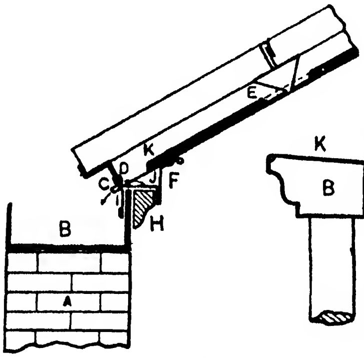


Fig. 126. Method of Fastening Lower Part of Skylight on Cast Iron Gutter

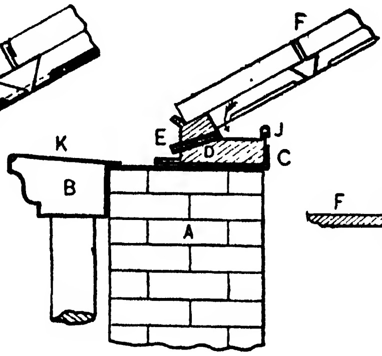


Fig. 127. Method Employed When Using Sheet Metal Gutter

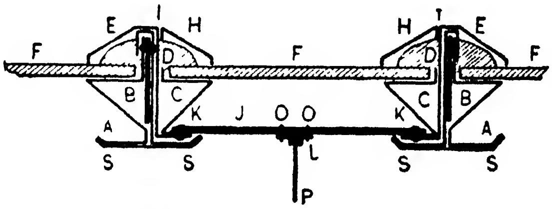


Fig. 128. Section Through Raising Sash

forming the sheet metal base. When there is no cast iron gutter furnished on the wall a gutter of sheet metal is used, one of the methods employed being shown in Fig. 127, in which A represents the brick wall and B the sheet metal gutter, flanged back the entire width of the wall and turned up at C, the gutter being fastened across the top by the brace K. D represents the base or the lower frame of the skylight, formed in a shape as shown, with the double seam or lock at J. A flange is bent outward, as shown at E, which is soldered to the galvanized iron covering on the wall. In the metal shape D wood blocking is placed as shown, through which at intervals the condensation tubes are placed, as shown by E. The bar F is mitered to the base as shown, the condensation dripping into the gutter of D, as shown by the arrow.

Suppose that A in Fig. 122 is to be made as a raising sash, hinged at the top, with gearings on the inside to operate from the floor below, the sash to be so constructed as to obtain a water tight joint when closed.

In Fig. 128 is shown a section through the raising sash, showing the method of construction. Where a raising sash is placed, instead of using a full shaped rafter a half rafter only is used, with a full condensation gutter, as shown by A A in Fig. 128. It will be noticed that A and A contain but half a bar, with full condensation gutter S S and S S, the core bar B B being riveted in place, as shown. C C shows the style of bars used for raising sash. The bar, including the cap, is made in one piece with a seam at D D, and the cap at E and E overlapping the glass lights adjoining. In the adjoining lights the glass F and F is

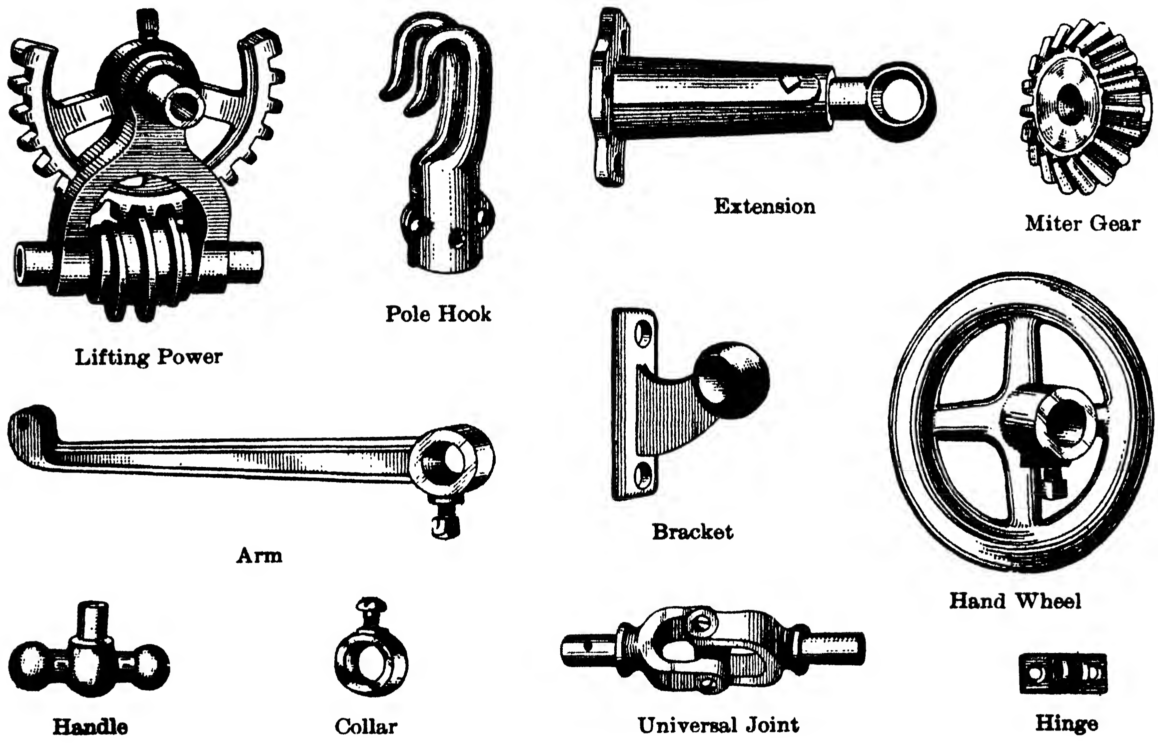


Fig. 129. Various Parts of Gearing Used in Raising Sash

laid on the bars, puttied as shown. In the raising sash the glass F is laid as shown, puttied, and the caps H and H soldered at I and I. The hinge or pivot being in position, the sash is raised, including the caps E and E, thus ventilating the space beneath, when closed the caps E E lay on to the glass F F, keeping the joint storm proof. When raising the sash this can be accomplished by means of poles, ratchet or gearings, the gearings being the most popular and successful in use. A band iron $1\frac{1}{4} \times \frac{3}{8}$ inch is riveted to the flange of the sash, as shown by K and K. On to this band iron the hinge L is riveted at O and O, to which the strap P is pivoted.

The various parts of the gearing employed in connection with a skylight of this kind, together with the name of each part, is illustrated in Fig. 129. The gearings can be obtained in various sizes, the more usual being for $\frac{3}{4}$ and 1-inch pipe. In Fig. 130 is shown the gearing in use. In this figure O represents the bracket fastened to the wall, P and R the lifting power with worm gear, G the pipe or rod, X the arm attached to the strap L at Y, and K the hinge. The handle bar is represented by T and the handle itself by S, these being kept from the wall at any distance desired by means of the extension U, into which the rod V slides, being fastened by the set screw W. The position of the fixtures in the engraving shows the sash closed. When opening the sash, turn the handle S until the desired hight is obtained. When the handle S is too far above the floor a pole is employed, on to which the pole hook shown in Fig. 129 is fastened. When a skylight runs around a corner of a building and the sash in the two sides are to operate with one lifting power, a miter gear is employed, as shown in Fig. 129, two of which constitute an angle. It is sometimes the case that the handle rod shown by T in Fig. 130 cannot run down straight, owing to some obstruction, and must pass over this obstruction at an angle. It is then that the universal joint shown in Fig. 129 is used. The collar shown in the diagram is used to keep the center pipe G in Fig. 130 from sliding back or forth between the brackets. Where a number of sashes are to be raised at one time and they can be reached without the use of the pole hook more power is obtained in using, instead of the handle S, the hand wheel shown in Fig. 129.

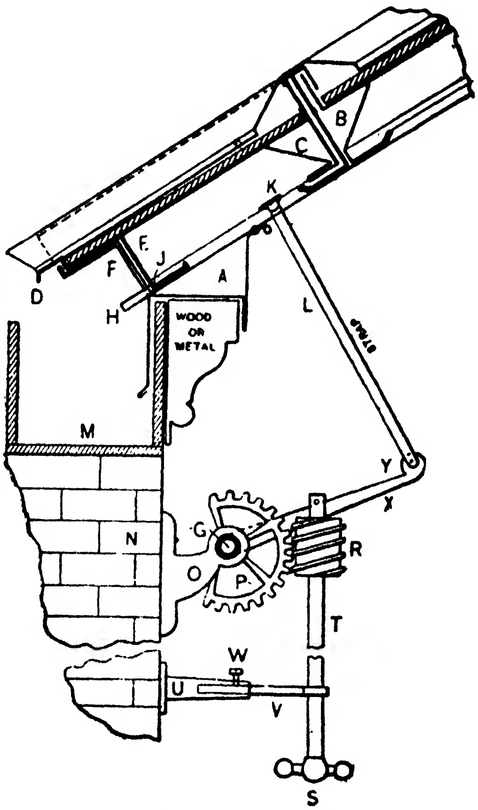


Fig. 130. Construction of Raising Sash at the Bottom

In Fig. 130 is shown the method of constructing the bottom of the raising sash so as to fit the lower frame of skylight. Let A represent the lower frame of the skylight and B one half of regular bar. C shows the sash bar, mitering against the base of sash, D E, which in turn fits on to F. The condensation tube is shown at H, and J indicates holes punched into the angle for the escape of water into the gutter A, thence through

the tube H. When the sash is lifted the sash frame D E will raise or lower from and into the frame F.

In Fig. 131 is shown the method of constructing and hinging the raising sash at the top. A shows the upper frame of the skylight, filled by the wood blocking D, while B shows the section of a half regular bar. C indicates the sash bar mitering against the upper sash frame E, which in turn fits against the frame D. By means of the hinge, F F, which is screwed into the wood blocking, the sash can be raised or lowered. The capping, H H, should extend up above the hinge as shown, then over this capping the flashing J J is mitered. Sufficient play room should be allowed, as at K, to permit the sash to raise without tearing up the upper flashing J J.

In Fig. 132 is shown the method of obtaining water tight cross seams in glass when the panes are of long length. When the span from wall to gutter is very

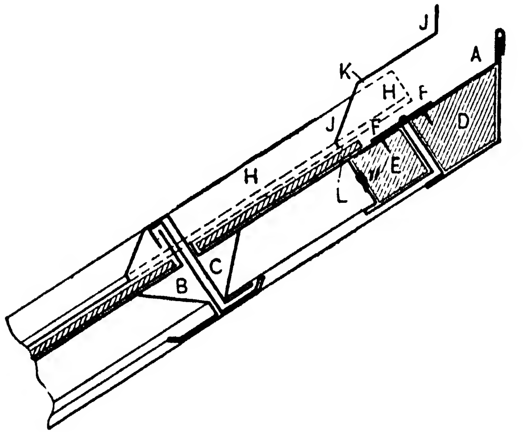


Fig. 131. Construction of Raising Sash at the Top

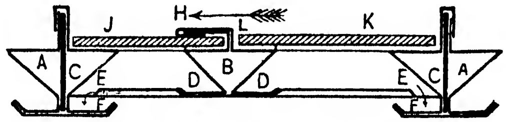


Fig. 132. Method of Constructing Cross Bar

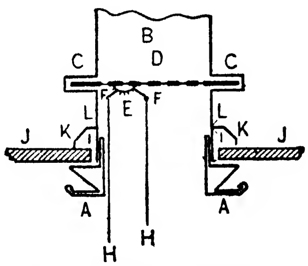


Fig. 133. Way in Which Register is Fastened in Ventilator

long it is usual to use T-iron for core bars and use light truss work under the flat lights. Assume that long rafters are employed and the glass must be used in two lights. Thus in Fig. 132 is shown how a water tight joint is obtained. Let A A represent the regular bars and B the cross bar, formed so that the bottom will cut into the corners C C of the regular bars. D D shows the condensation gutters notched out at E E so that in case of any leakage the water runs out at E E in the main bar gutters F F and out at the lower tubes. H shows the flange bent downward to suit the thickness of the glass used. The glass J is slipped under the flange H and the glass K run flush with L, both bedded well in putty. The water flowing in the direction of the arrow no leak can result.

In Fig. 133 is shown the method of fastening and controlling the register in ventilators. Let A A represent the half regular bars, over which the ventilator

is placed as shown at B, while C C show the grooves formed on to the ventilator, into which the register D is placed. By means of the quadrant E the louvres in the registers can be opened or closed by means of the cords or chains F H. The glass J and J is now laid, bedded into putty at I and I, and the caps K K soldered against the ventilators at L L.

PROFILES OF BARS IN AN IRREGULAR SHAPED SKYLIGHT

In the following will be exemplified the method of how to obtain the shapes of the different rafters in an extension skylight, such as is shown in Fig. 134. The bars or rafters rest on an iron beam which is built into the wall at the top, as shown in section, and there is a channel beam resting on the rear wall, which has a pitch of 3 inches in 24 feet. The skylight is 3 feet wide at one end and 11

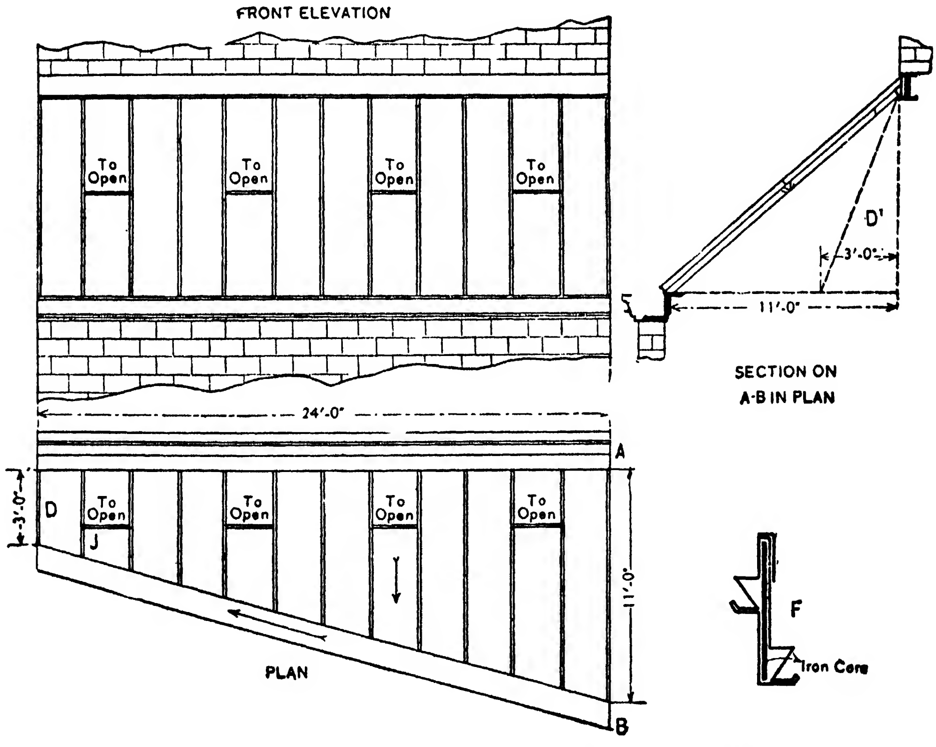


Fig. 134. Plan, Elevation, Section and Profile of Bar

feet at the other. It is desirable to obtain the various shaped rafters, also profile of the twisted top ridge and bottom curb, so as to bring the glass rests on the curb, rafter and top ridge in one plane, to receive the sheet of ribbed glass.

The method of obtaining the patterns will not be shown, as this is a simple matter when the profiles are known. Fig. 134, a reproduction of the job in

question, shows a front elevation of the extension skylight with four lights to open, while the plan shows the dimensions of the skylight. A section is also drawn on the widest portion, or A B in plan. D^1 in the section shows the length of the bar at the smallest projection of the skylight or D in plan. F shows the bar desired, with iron core in position. Water pitches toward the narrow end of the skylight and has a fall of 3 inches.

To show the principles employed in obtaining the various profiles of the top ridge and bottom curb, refer to Fig. 135, which shows a skylight 11 feet at one end, 3 feet at the other end and 16 feet long, the curb having a pitch of 3 inches, as shown. Draw, in its proper position, the curb 1 2 3 B and the ridge A 4 5

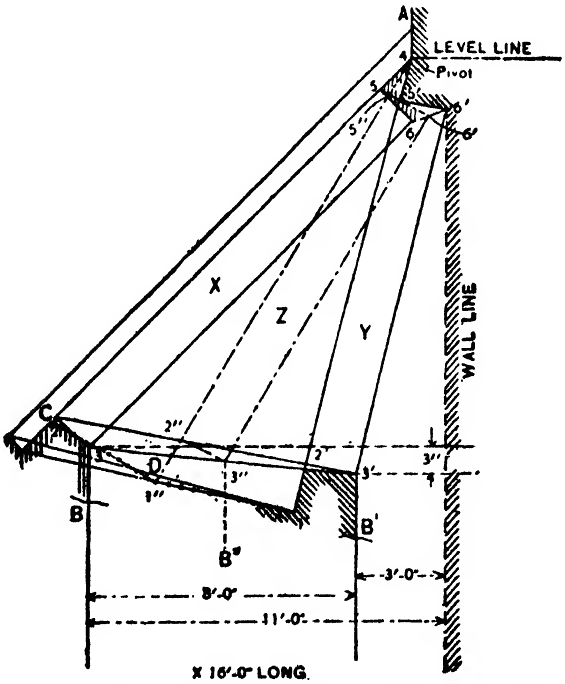


Fig. 135. Obtaining Profiles for Top Ridge and Bottom Curb

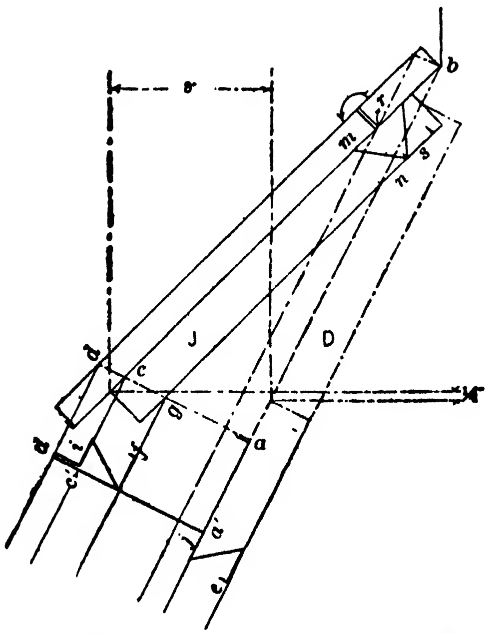


Fig. 136. Obtaining Profiles for Rafters

6, as shown, to which connect the bar X. In a similar manner draw, in its proper position, or 3 inches below the curb B, the profile 1′ 2′ 3′ B^1 and the ridge A 4 5′ 6′, and connect the bar Y.

It will be noticed that the curb and ridge have been drawn at right angles to the rake of the bars, so that the only change of profiles taking place are the angles 2 3 B and 2′ 3′ B^1 in the curb and A 4 5 and A 4 5′ in the ridge at the wide and narrow ends respectively. As the length of the skylight is 16 feet, or two sheets of iron of 8 feet each with one seam in the center, another change of profiles must be obtained. To do so proceed as follows: Connect the curb lines 1

to 1′, 2 to 2′ and 3 to 3′. Bisect all of these lines, obtaining the points 1″, 2″, 3″ and B², which connect by the dotted lines, as shown. Then will one end of the first sheet, when forming, have a shown by 1″ 2″ 3″ B²; the one end of the second sheet, a shape as shown by 1 2 3 B, and the opposite end as shown by 1′ 2′ 3′ B¹.

In similar manner obtain the change of profile in the ridge. Then will A 4 5″ 6″ be the true profile for the end of the first and commencement of the second sheet, while A 4 5 6 is the profile for the commencement of the first sheet and A 4 5′ 6′ the end shape of the second sheet. It will be noticed that the point 4 remains stationary and acts as a pivot which changes all angles, as shown by A 4 5, A 4 5″ and A 4 5′. Connect the center profiles by the bar Z.

If the widths of the wide and narrow ends were 11 and 3 feet respectively, as shown, and the length of the skylight 24 feet, then divide 24 by the length of the cornice brake in use, in this case 8 feet, which will give three sheets. Then would the diagram in Fig. 135 be divided into three equal spaces, thus giving two changes of profiles. As each one of these spaces would represent 8 feet, then for any fractional part of a foot the following method could be employed:

Assuming that the length of the skylight is 25 feet 6 inches, divide the space shown from 3 to 3′ in curb and 6 to 6′ in ridge into 51 equal parts, representing 51 6-inch spaces. Then would 16 spaces represent 8 feet, 48 spaces 24 feet and the balance of three spaces 1 foot 6 inches. In this manner the various profiles are obtained for curb and ridge.

In Fig. 136 are shown the principles employed for obtaining the profiles of the rafters. Let D represent the section of the rafter shown in plan in Fig. 134 by D, and J in Fig. 136 the rafter on J in plan in Fig. 134, both having been obtained as explained in connection with Fig. 135. As the gutter has a fall of 3 inches in 24 feet, and assuming that the lights are to be 2 feet wide, as shown in Fig. 134, then will every 2 feet distance have a pitch of ¼ inch, which is shown in Fig. 136, where the curb of the rafter D is ¼ inch below the curb of the rafter J. As the narrow end of the skylight in Fig. 134 is 3 feet and the wide end 11 feet, deduct 3 from 11, which leaves 8. As there are 12 lights of glass of 2 feet each, then will the pitch of every light in plan equal 8-12 foot, or 8 inches, which is shown in Fig. 136 from curb to curb. In this manner the various sections on the rafter lines in plan in Fig. 134 are obtained.

At right angles to the rafter lines D in Fig. 136, and from the extreme point, as at *a*, erect a line, as shown, intersecting the outer line of the rafter J at *d* and crossing the various bends in the bar J at *c* and *g*. At right angles to *d a*, and

from the intersections just obtained, draw lines as shown. Draw the line *a' c' d'*, and make the glass rests *i* and *j* equal to *m*, and the condensation gutters *f* and *e* equal to *n* in section *m n s r*. Then will *f d' a' e* be the profile of the bar on *d a*.

When laying out the pattern for the bar D, the upper shape at *b* is as shown by *m n s r*, while the lower half is as shown by *e j a'* with the triangular piece added, as shown by *a b c*, and on the line *b c* of the triangular piece add the stretchout of the profile *r m n* and not of the profile *d' i f*, as that is a section on the line *d g*. Thus it will be seen that the miter cuts will be square at the curb and ridge, so that a cut for one bar will answer for all. The only changes taking place are in the lengths of the triangular pieces for each bar, as shown in Fig. 135.

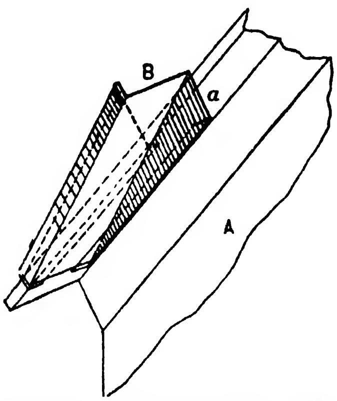


Fig. 137. Wedge Shaped Glass Rest Between Rafters

When the various bars are soldered in position at the building it will be necessary to put in wedge shaped sections on the lower curb, as shown in Fig. 137 by B, so as to bring the glass rest on the curb in a horizontal plane to receive the glass. A shows the curb on which the wedge shape B is placed, the hight of *a* being obtained from *c' a'* in Fig. 136. On each bar this hight varies, as shown in Fig. 135.

CONSTRUCTING A SLOPING SKYLIGHT

It is the intention of this article to treat on the method of constructing a skylight 8×12 feet, the 12-foot measurement being along the slope of the roof. The rafters are 12 feet long, and it is necessary to provide glass in two or more pieces for each section. Two openings must be provided in the top of the skylight for ventilation. The ventilator or hood is to be made so that when it is closed it will be nearly flush with the rest of the construction.

In Fig. 138 A B shows the side and C D E F the front of the skylight. G and H represent the cross bars or clips, which are used where more than one length of glass must be used, while J J show the two ventilators at the top. These are shown in side view by I. Figs. 139 to 142 show the various cross sections through K L, M N, O P and R S. A and B in Fig. 139 are the metal curbs, setting over the wooden curbs after they are flashed with metal. C is the rafter, reinforced by the lower strip D, locking same as shown. Inside

the rafter a core plate, shown by E, is placed, riveted at F. If the skylight be trussed through the center the core plate E in Fig. 139 will be strong enough if made of $\frac{1}{8} \times 2\frac{1}{2}$-inch metal. If no truss is to be placed through the center, the core should be $\frac{1}{4} \times 4$-inch metal, and wooden cores should be placed in the metal

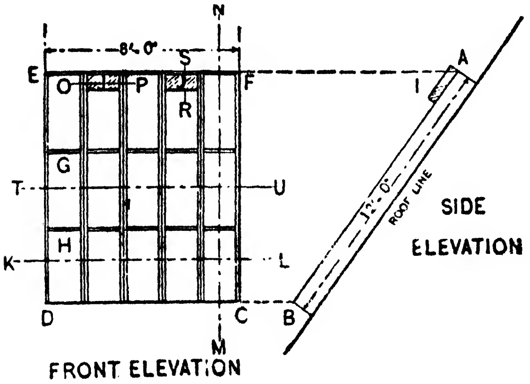


Fig. 138. Front and Side Elevation

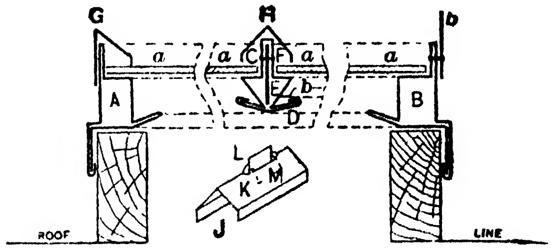


Fig. 139. Section Through K L in Fig. 188

curbs, shown by A and B in Fig. 140, so that metal core plates will have a solid bearing when they are cut out at the top and bottom to conform with the metal curbs, at both top and bottom.

a, *a*, *a*, *a* in Fig. 139 show the glass resting on the rabbets, which should be well puttied and capped by the metal caps G and H. When fastening these metal caps copper cleats, about $\frac{1}{2} \times 1\frac{1}{2}$ inches, are riveted about 24 inches apart along the curbs and bars. When fastening the cap a slot is cut in the cap in its proper place, as shown at K in J, and slipped over the copper cleat L, which is, in turn, turned over the cap, as shown by M, holding the cap in position. It will be noticed

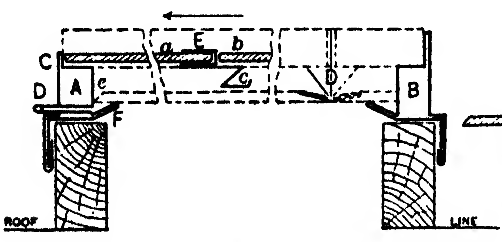


Fig. 140. Section Through M N in Fig. 188

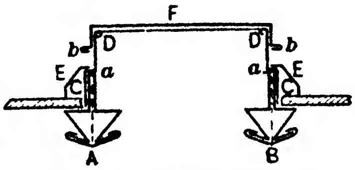


Fig. 141. Section Through O P in Fig. 188.

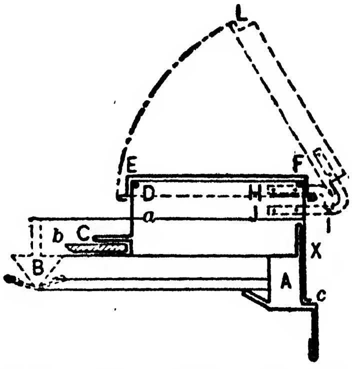


Fig. 142. Section Through R S in Fig. 188

that the rafter C is made so that its bottom will pass above the condensation gutters of the curbs A and B.

A and B in Fig. 140, the section through M N in Fig. 138 are the metal curbs resting on and over the wooden curb. Using this construction, it will be seen that the curbs are similar along the four sides of the skylight, with the exception that the double edge at C is shortened, so that it is equal to the thickness of

glass in use, and that a condensation tube passes through the curb A at D, to carry off any condensation which might gather in the lower gutter F. D shows the section of the main bar, from which elevation lines are projected, so that the cross bar or clip E can be properly drawn. The arrow indicates the run of the water. Notice how the clip is bent, so that the glass *a* will enter the groove shown, while the following light, *b*, runs flush with the top flange E, all to be well bedded in linseed oil putty. A condensation gutter is added to the clip at *c*, so that it will pass above the top of the condensation gutter of the bar D. This gutter, *c*, will catch any condensation, or, in case of a leak at *b*, will catch the rain water and empty it into the gutter of the main bar, as shown at *b* in Fig. 139. The main bar carries it to the lower gutter, in the curb A in Fig. 140 at *e*, thence through the condensation tube D to the roof.

Fig. 141, the section through O P in Fig. 138, shows the construction of a simple ventilator or hood. A and B represent the 12-foot rafters, on either side of which a curb is formed as wide as the desired width of the ventilator, as shown by C D, with a wire edge at the top to stiffen same. The angle formed at *a* and *a* rests on the top of the bar and forms a surface on which to solder the half caps E and E, covering the glass. The hood F is bent, as shown, with a hem edge at *b* and *b*. The method of operating this hood is shown in Fig. 142, a section through R S in Fig. 138. A in Fig. 142 shows the top curb of the skylight and B a profile of the rafter, from which elevation lines are drawn. Knowing the length of the ventilator, draw the lower part of the curb of the ventilator, bending it in such a manner that the glass *b* enters the groove prepared for it at C, and making the distance from the top of the bar *a* to the top of the wire edge D equal to *a* D in Fig. 141; 2 or 3 inches is sufficient for this hight. Then draw the back of the curb X in Fig. 142, allowing an edge at *c* for soldering. E F is the hood. A hinge, constructed as shown by H I J, is riveted to the hood at H and to the ventilator curb at J, the pivot being at I. The hood when opened swings clear off the ventilator, as shown by L. These hinges can be made from band iron. The hood can be operated by cord and pulleys, or by one of the many appliances upon the market.

REMARKS ON CURBS AND BARS

The curb of Fig. 143 is considered ideal because of its many features essential to perfect service, chief of which is, that as roof curbs are seldom cut on the slant necessary to have the part B C pitch to apron A and thereby requiring a shoulder

or straight bearing part, and as the curb of Fig. 144 retains the water of condensation in the part B A, whereas C B of Fig. 143 rapidly drains the water to the outside. The curb shown in Fig. 145 is a method employed for a combination concrete and angle iron curb and shows the method of anchoring it, also the tube A which had the double service to perform, that of directing the condensation to the roof and as a brace to keep down the apron A A. The idea of having the

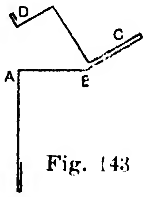


Fig. 143

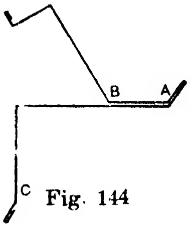


Fig. 144

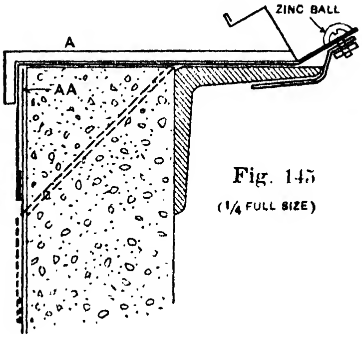


Fig. 145
(1/4 FULL SIZE)

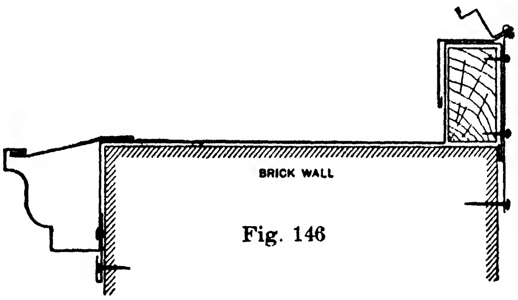


Fig. 146

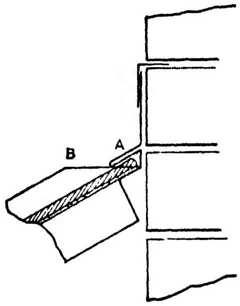


Fig. 148

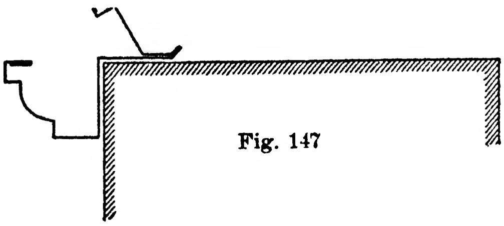
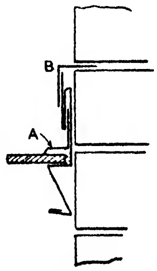


Fig. 147



Some Features of Skylight Work

Fig. 149

glass rest so far back was to save glass, and as a suggestion it is submitted that if the cement curb was beveled the apron A A could be made on a slant as shown by the dotted lines, obviating the need of the brace A, though it would be advisable to use a small tube. As will be seen this is the same curb as Fig. 143, also by adjusting the part A B of Fig. 143 the curb can be employed for any size roof curb, without disturbing the miter cut of the curb, except of course, the part from A to B of Fig. 143.

In Figs. 146 and 147 are shown two methods of setting skylights on brick wall of considerable thickness, say a 16-in. wall. With the idea of saving glass and the superstructure of the skylight, Fig. 146 is considered excellent. As will be seen by an inspection of Fig. 146, the skylight curb is set on a wood plate that is framed flush with the inside of the wall, all being enclosed as shown. The gutter is set on the outer edge of the wall and to keep it from raising it is tied down by sheet metal straps, riveted and soldered to the gutter and nailed in a joint of the brick work. The flange of the gutter extends back to the plate, up and over it and down past the bottom of the plate to hide the joint between the plate and wall. If the wall is of excessive width it is advisable to pitch this part of the gutter.

As to the custom of bending a stiffening edge on the apron of curb as at C, Fig. 144, it could be said that the edge is useless, for in the handling of the skylight the edge would be considerably bruised and the bevel edge would be a series of buckles, defeating the purpose of keeping the apron stiff and straight. It would be best to simply turn a hem edge as in Fig. 143, then after setting, it can be dressed back to the roof curb as it is customary to do. Few shops turn the flashing of the roof back on the top of the roof curb; preferring to save time and material they just bring it even with the top of the roof curb as shown at A A of Fig. 145. This procedure is not objectionable, for is not the flashing and apron of the skylight curb exactly like the base and cap flashing at a wall in roofing? Surely, no roofer would turn a base flashing into a wall and then cap it.

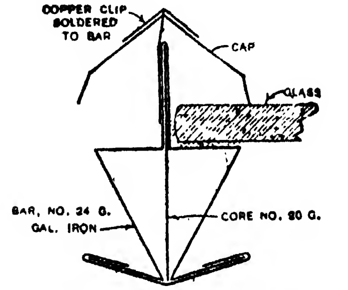
If bars are of heavy material, a $\frac{3}{4}$-in., or more, shoulder is best, for in bending heavy stuff all machines make a rather round bend which will take about $\frac{1}{8}$ of an inch, thereby making a $\frac{5}{8}$-in. glass rest or shoulder when $\frac{3}{4}$ in. is allowed. Too much stress cannot be laid on the need of making the condensation gutter of the bar extend beyond the glass rest, for this is the only guard against leakage of the skylight. In the mad desire to save material, many designers reduce this gutter to almost nothing. In Fig. 148 is shown a section of a bar when it abuts a wall, or can be the profile of the neck part of a ventilator. When the side of a skylight finishes against a wall, the side bar can be made as per Fig. 149. In the conventional method of designing the profiles of Figs. 148 and 149, the flashing must be put in after the skylight is glazed and if a light is broken, all the work must be ripped out to replace the glass; whereas, with the profiles of Figs. 148 and 149 the flashing is done before glazing; the cap A in Fig. 148 is integral to the bar part as the glass can be shoved under it; and in Fig. 149 a pocket is formed in the bar part to allow of slipping the cap in place after glazing. In the matter of riveting,

it is well to rivet all bars to the curb, but at the ridge the weight of the glass will jam the bars against the ridge, even holding them without solder, and as long as the thrust is equalized at the curb the skylight would not collapse in a fire.

DETAILS OF SKYLIGHT WORK

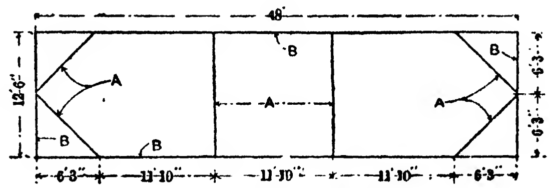
The many requests for information resulted in the answer to one for a skylight 12 ft. 6 in. × 48 ft. in size, with glass at hand of a size of 48×84 in. The reply stated that the glass be split into lights 24 inches wide, as it is rather risky to use glass spanning 48 in. in width when the glass is, or nearly, in a horizontal plane, it being advisable never to have the glass exceeding 24 in. wide, and 18 in., is a favorite width.

A light of glass $\frac{3}{8} \times 24 \times 84$ in. weighs 70 lbs. and as this weight is distributed



RIDGE & HIP SIMILAR, BUT TO REQUIRED PROFILE

Fig. 150. Type of Skylight Bar



A RODS; B ROOF CURB.

Fig. 152. Sketch of Roof Framing

the entire length of bar, a bar of the dimensions and shape of Fig. 150 should be of ample strength for this load, allowing for possible wind and snow stresses, without perceptible deflection. As the skylight curb is not only subjected to strain of bearing the weight of the glass and the like, but also the outward thrust of the bars and glass, it should be tied to maintain an assurance that it will not spread.

Fig. 151 illustrates a design of skylight curb, to be set on a wood roof curb, and calculated to be of sufficient strength for a skylight of the size under consideration. By securely anchoring the skylight curb to the roof curb by means of the wood screws shown, the stresses will be transmitted to the roof

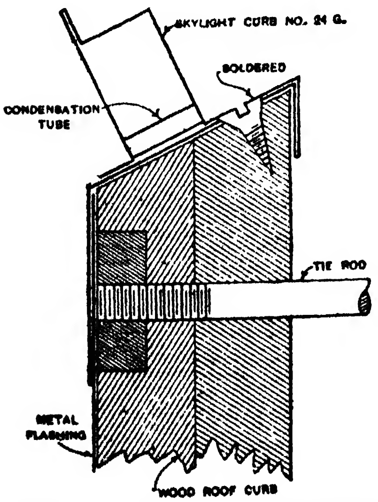


Fig. 151. Construction of Skylight Curb

curb which should therefore be built in a manner to take care of all strains, and then instead of tying the skylight curb, and if the roof curb, by reason of its construction relative principally to hight, requires it, the roof curb may be tied by rods and turnbuckles spaced according to Fig. 152.

A CHART TO FIND THE LENGTH OF BARS

The following is a description with illustrations of a chart that has been used for obtaining directly the length of bars for a hip skylight.

It will be observed that for convenience in publishing this chart it is drawn on a ¼-inch scale, and for the purpose of illustrating its working there was used a pitch of skylight that is about 7 inches to the foot; but any other pitch of skylight is equally applicable. For practical use in the shop the chart should be drawn full size in order to secure accuracy in determining the length of the various bars required.

The use of the chart as shown in Fig. 153 presupposes that the ground plan of the skylight has been properly laid out, as regards spacing off and locating the position of the bars. As the chart indicates, all measurements are taken from the curb line of the skylight.

It will be observed that the chart is triangular in form and its base, A B C, a right angle triangle, and the same as one-half of the ground plan of the end of a skylight. A B, as the base of this right angle triangle, represents the curb or measuring line of the skylight. The line A C represents the ground plan of the side bar C *e*, drawn at right angles with A C and of sufficient length to give A *e* the proper pitch of the skylight. On this line A *e* is laid off a rule or measuring bar representing inches and quarter inches, by which to determine almost at a glance the length of bar required at any given point. In the same or like manner, B C represents the ground plan of the hip bar. At point C draw the line C *d* at right angles with B C and of the same length as C *e*, and this gives B *d* on which to lay off the measurements for the hip bar. Draw lines from the measurements laid off on the curb line A B and intersect them with hip line B C at points 1, 2, 3, 4, etc., and from these various points for the hip bar continue these lines at right angles with B C and intersect them with the line B *d* as points of measurement. For the side bar draw lines from these same points 1, 2, 3, 4, etc., on this same line B C and at right angles with A C, intersecting them with the line A *e*. Thus is established A B as the measuring line of the curb of skylight, A *e* as the measuring line of the side bar, and B *d* as the measuring line for the hip bar.

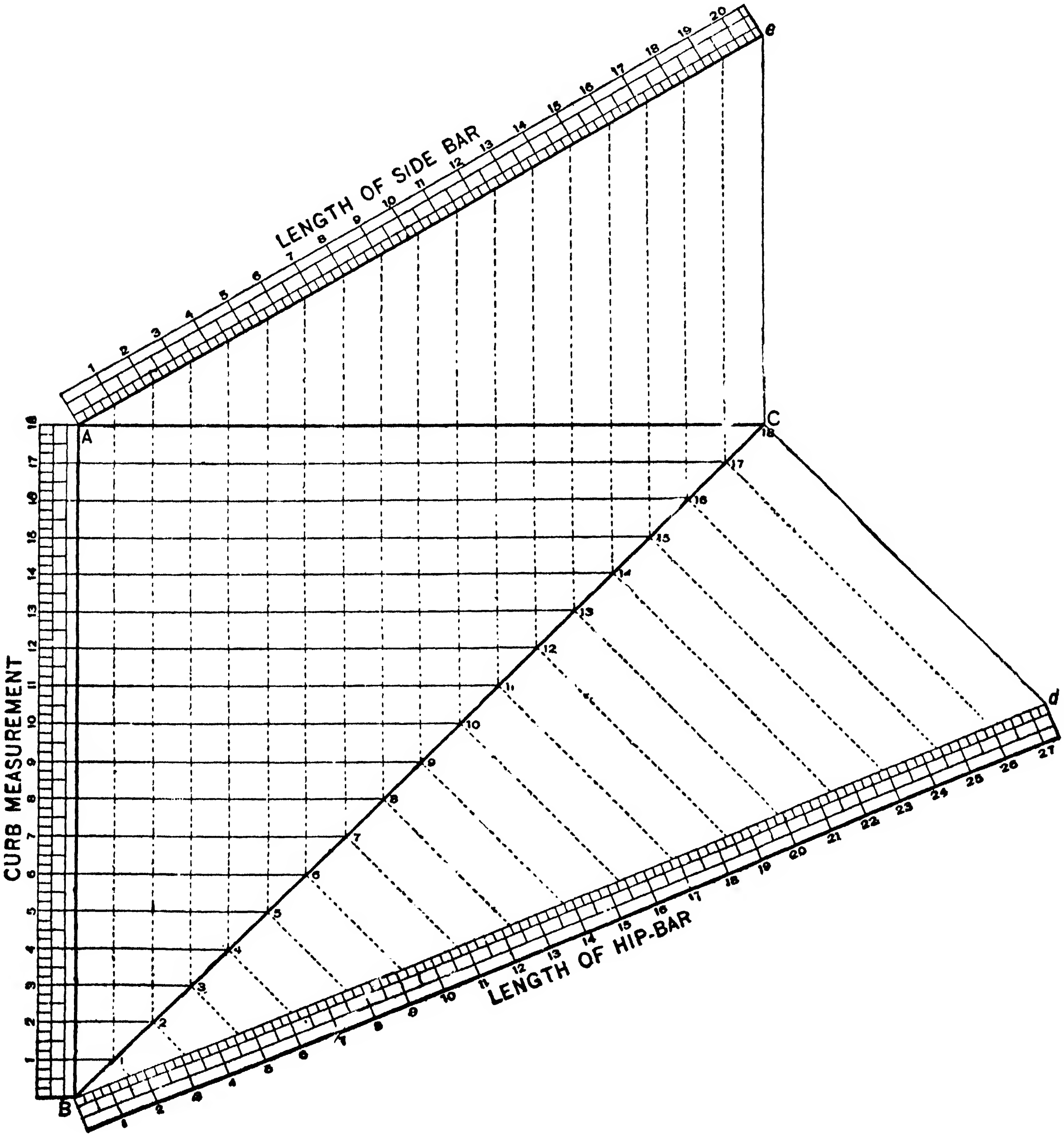


Fig. 158. The Skylight Chart

A little practice will enable one to read readily the length of any bar required. While the measurement of the curb is on the line A B, the points 1, 2, 3, 4, etc., on the line B C represent so many inches respectively of the curb measurement. To illustrate: In Fig. 154 is represented a skylight 2×3 feet. The curb measurement of this skylight, being one-half of the end of the same, is 12 inches. Referring to the chart, 12 inches is the curb measurement, or as shown by the number 12 on the line B C. Follow the dotted line from point 12 on B C to its intersection with line A *e* and it gives 13⅞ inches as the length of side bar, as shown by A C in Fig. 154. To find the length of the hip bar, as shown by B C in Fig. 154, follow the dotted lines drawn from the same point 12 on line B C of the chart to its intersection with B *d*, and obtain 18⅜ inches as the length of the hip bar B C, as shown in Fig. 154.

Let it be supposed now it is required to find the length of bars for a skylight that is larger than is represented on the chart. For example, in Fig. 155 a skylight 10 feet square. In this skylight it is required to find first the length of the hip bar K. The distance A B of this skylight represents one-half of the width of the skylight, or 5 feet, as the curb measurement to be applied to the chart. But it is found that the chart does not cover 5 feet in length of curb measurement, so take some number that is represented and that will go into 5 feet, or 60 inches, a given number of times. The highest number on the chart that will do this is 15 inches. Fifteen inches will go into 60 inches just four times. It is found by referring to the chart that 15 inches curb measurement gives 22⅞ inches as the length of the hip bars, as shown on line B *d*. Twenty-two and seven-eighths inches multiplied by four gives 91½ inches, the length of hip bar K in Fig. 155. To get the length of side center bar D of Fig. 155 it is found that the curb measurement of 15 inches gives on the side bar measurement on line A *e* 17¼ inches. Seventeen and one-quarter inches multiplied by four gives 69 inches for the length of this center side bar D.

To get the length of the bars H and E, as shown in Fig. 155, it is first found that the curb measurement for the H bar is represented by B *b*. B *b* is one-sixth of the distance from B to F, and as B F represents 10 feet, or 120 inches, B *b* is one-sixth of 120 inches, or 20 inches. Twenty inches, then, is the curb measurement from which to determine the length of the bar H. Twenty inches not being represented on the chart, take the measurement of two numbers that are its equivalent, two tens. Ten inches curb measurement gives on the side bar A *e* 11½ inches, which multiplied by 2 gives us 23 inches as the length of bar H. To get the length of the bar E, the curb measurement B *c*, as shown in Fig.

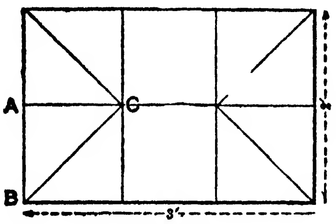


Fig. 154

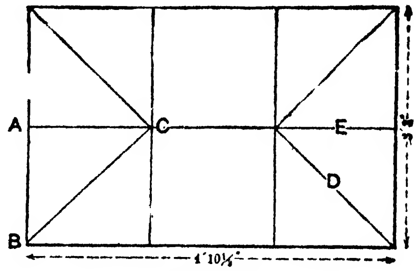


Fig. 156

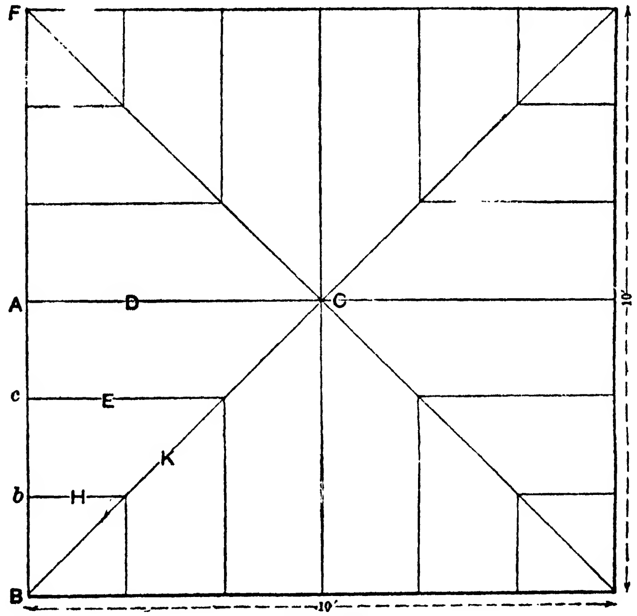


Fig. 155

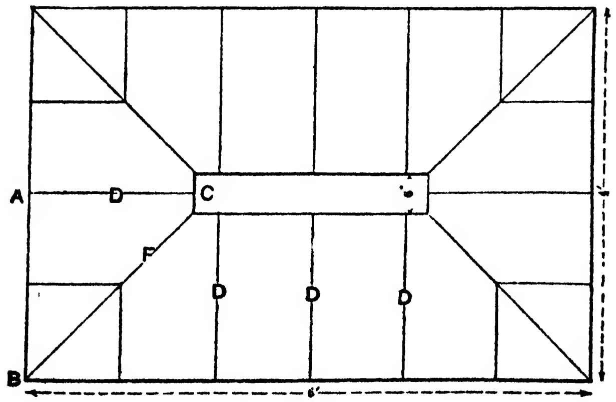


Fig. 157
Plans of Typical Skylights

155, being twice as long as B *b*, the length of the bar E would be twice as long as the bar H, or 46 inches.

This same principle applies alike in the development of these bars in all cases and in hip skylights of any size or dimension, bearing in mind, however, that the curb measurement of the bar is always the distance from the center of the bar on the curb line to the corner of the skylight, as shown respectively by *c* B and *b* B in Fig. 155.

Suppose now an odd size skylight is taken, as shown by Fig. 156. This skylight is 3 feet 3 inches wide, or 39 inches. This would make the curb measurement 19½ inches. As 19½ inches is not represented on the chart and is not divisible by any number of inches it represents, take the sum of two numbers that represent 19½ inches, and added together will give the length of bar required. For example: Take any two numbers, as 15 and 4½, which, added together, will give the length required for the bars D and E, shown in Fig. 156. It is found that 15 inches curb measurement on the chart gives for the length of the hip bar on line B *d* 22⅞ inches, and 4½ inches curb measurement gives on the same line B *d* 6⅞ inches, and these added together give 29¾ inches as the length of the hip bar D in Fig. 156. In like manner 15 inches curb measurement on the chart gives 17¼ inches on side bar measurement A *e*, and 4½ inches curb measurement gives on this same line A *e* 5⅛ inches, which added together gives 22⅜ inches as the length of the side bar E, Fig. 156.

Thus far it will be observed that the length of bar developed has been in skylights with no ridge ventilation. For skylights where there is ridge ventilation, in order to secure the proper length of the center end bar and middle side bars D D D D, as shown in Fig. 157, it is necessary to first deduct the width of the opening for the ventilator, 6 inches, and then take one-half of the balance as the curb measurement. Fig. 157 represents a skylight 4 feet wide, or 48 inches; as the width of the opening for the ventilator is 6 inches, deduct the 6 inches from the 48, which leaves 42 inches. One-half of 42 inches gives 21 inches as the length to be applied to the curb measurement of the chart in determining the length of the bars D D D D. As 21 inches is not represented on the chart, take any two numbers that are represented and the sum total of which equals the 21 inches. But when there is not too great a fraction involved it is more convenient to take a number that will go into it an equal number of times. Twice 10½ inches is equal to 21 inches; 10½ inches curb measurement gives us 12⅛ inches on the line A *e*; 12⅛ inches$\times 2 = 24\frac{1}{4}$ inches, the length of the side bars D D D D. To get the length of the hip bar F shown in ground plan, Fig. 157, 10½

inches curb measurement gives on the line B d 16 inches; 16 inches×2=32 inches, the length of the hip bar F.

As already stated, all measurements for the length of bars on this chart are at the curb line of skylight.

It is understood that all skylight makers do not use the same pitch to their skylights, some preferring one pitch and some another. It is desirable, therefore, to call attention to the fact that the chart can be readily adjusted to meet all of these conditions and to suit any pitch of skylight required. This is done by lengthening or shortening the lines C e and C d, Fig. 153, which represent the hight of skylight, accordingly as the pitch required is greater or less than represented on the chart. The lengthening or shortening of these lines, C e and C d, in no way affects the measuring bars on line A e and on line B d, except to increase or diminish their length.

The base line, as shown by A B, and which represents the curb measurement of the skylight, can be increased to any length desired. But for convenience in handling as a chart of reference in the workshop it is not desirable to have it too large. It is considered that a chart with a base line of 2 feet wide is sufficient for all practical purposes in securing accurate measurements for the length of bars in any size skylight, as was fully shown and explained in the description above.

COMPUTING THE LENGTHS OF SKYLIGHT BARS AND RAFTERS

It is the intention of this article to explain the method of computing the length of bars without using diagrams or charts. The rule used for obtaining the lengths of bars by computation is based on the geometrical principle, that the hypotenuse of a right triangle is equal to the square root of the sum of the squares of its base and altitude.

Fig. 158 shows a right triangle, the bar of which, A B, is 3 inches; altitude, B C, is 4 inches and hypotenuse, C A, is 5 inches. The square of 3, as shown, is 9; the square of 4 is 16 and the square of 5 is 25; adding 9 to 16 gives 25; thus demonstrating that the sum of the squares of the base and altitude is equal to the square of the hypotenuse. Extract the square root of 25 which is 5, because 5×5=25, which proves the above principle.

To show how this principle is applied to skylight work let Fig. 159 represent a section of a single pitched skylight, butting against the wall A B, and resting on

the curb C. D shows one of many different shapes of the skylight frame, having its upper edge, *a* in a vertical line with the outside of the curb, as shown, thereby making the distance from *a* to *c* the same distance as from *b* to B. It is important that one of the intersections of the bar will come in a vertical line with the outer

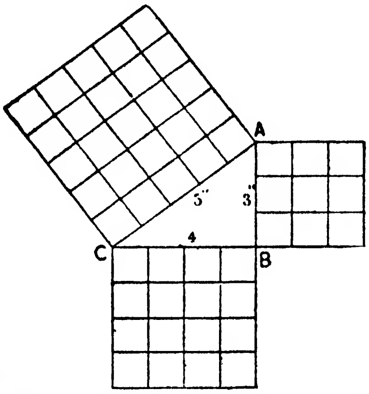


Fig. 158. A Right Triangle with Squares Erected on its Sides

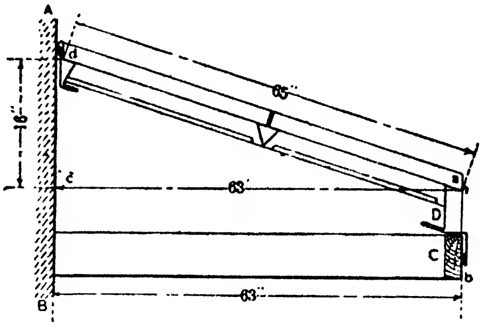


Fig. 159. Section of Single Pitched Skylight

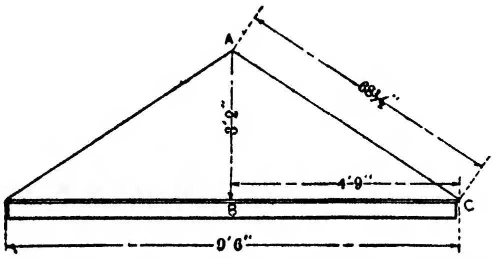


Fig. 160. Section of Double Pitched Skylight

curb *b*, as shown in this case at *a*, for then the distance from *b* to B, which in this case is 63 inches, can be used for the base measure in computing, as shown from *a* to *c*; then when the length of the bar is obtained it can be measured on similar points, as from *a* to *d* on the hypotenuse or bar. Assuming in this single pitched skylight that the base from *a* to *c* is 63 inches, the rise or altitude from *c* to *d* 16 inches, then by the above principle the length *a d* is equal to $\sqrt{63^2 + 16^2}$, or $\sqrt{4225}$, or 65 inches, and is figured as follows: The square of 63 is equal to 63×63, or 3969; the square of 16 equals 16×16, or 256; $256 + 3969 = 4225$, from which the square root is to be extracted, or the number which, when multiplied by itself, will give 4225 as the product. Starting from the right (if no decimal point is used), separate the number into periods of two figures each, as shown:

Trial divisor.	Correct divisor.	42'25 (65 ans.
120	125	36
		625
		625

Find the greatest number the square of which is contained in the first or left hand number, 42; $7 \times 7 = 49$, and is too large a number; then take 6; $6 \times 6 = 36$, therefore 6 is the first figure of the root. Subtracting 36 from 42 obtain 6, and bringing

down the next period (25) obtain the first partial dividend, 625. Double the part of the root (6) already found and annex a cipher to it for the trial divisor, as shown by 120. Divide the trial divisor, 120, into the partial dividend, 625, which suggests 5. Add 5 to the trial divisor, 120, which gives the correct divisor, 125, which is contained in 625 five times and leaves no remainder. Therefore 65 is the required square root of 4225, because $65 \times 65 = 4225$, and is the length of the bar from *a* to *d* in Fig. 159.

When the same principle is applied to a double pitched skylight it should be borne in mind that the base measurement is always one-half of the narrow side of the curb; also remembering what was said about the points *a* and *b* in Fig. 159. In Fig. 160 is shown the section of the narrow end of a double pitched skylight 9 feet 6 inches wide, the length being immaterial. It will be assumed in constructing this skylight that the patterns which have been cut for one-third pitch will be used. As one-third pitch equals one-third the span, then one-third of 9 feet 6 inches equals 3 feet 2 inches, or the altitude, while one-half the width equals half of 9 feet 6 inches, or 4 feet 9 inches, or the base. This gives the right triangle A B C, the base of which C B equals 57 inches, and the altitude, B A, equals 38 inches. Proceeding as before, $57^2 = 3249$; $38^2 = 1444$; $3249 + 1444 = 4693$, the square of the bar A C. $\sqrt{4693} = 68.5+$, as follows:

Trial divisor.	Correct divisor.	46'93.00'00 (68.5 + Ans.
		36
120	128	1093
		1024
1360	1365	6900
		6825
13700		7500

Starting from the right of 4693, separate into periods of two figures each, as shown. Find the greatest number the square of which is contained in 46, which is 6, and is the first figure of the root. Subtract 36 from 46, which leaves 10; bring down the next period, 93, and get the first partial dividend, 1093. Double the partial root 6, which equals 12, and annex a cipher to it for the trial divisor, as shown by 120. Divide the trial divisor, 120, into the partial dividend, 1093, which suggests 9 as the second figure of the root. Adding 9 to the trial divisor, 120, get as the correct divisor, 129. But $129 \times 9 = 1161$, which is greater than the partial dividend, 1093, showing that 9 is too large a number for the second figure of the root. Taking 8 in place of 9 for the second figure of the root obtain 128 as the correct divisor. Subtracting the product of 8×128, or 1024, from 1093, get the remainder

69. Since it is necessary to obtain a decimal in the root annex two ciphers to 4693, as shown, and bring them down to 69, and obtain the second partial dividend, 6900. Since all the complete periods have been brought down, insert the decimal point after 8 in the root. Now double the partial root 68 and annex a cipher and get 1360 as the second trial divisor. Divide the second trial divisor, 1360, into the second partial dividend, 6900, which suggests 5. Adding 5 to the divisor 1360 get 1365 as the correct divisor, and 5 becomes the third figure in the root. $5 \times 1365 = 6825$. Subtract this from 6900 which leaves 75. Annex two more ciphers to the integer, as shown, and bring them down to 75 and get the third partial dividend, 7500. Double the partial root 685 and annex a cipher and have for the third trial divisor 13,700. This divisor is not contained in the partial dividend, 7500; therefore, the fourth figure of the root is 0. Hence, correct to three figures, the square root of 4693 is 68.5, or 68½ inches, for the length of the bar A C in Fig. 160. The length, 68.5, is the merest trifle short, for $68.5 \times 68.5 = 4692.25$. Assuming that the frame of the skylight is constructed as shown from *a* to *b* in Fig. 159, the length of the bars for a skylight 9 feet 6 inches wide, as shown in Fig. 160, would be 68½ inches, measured from A to C, using the set of patterns cut for one-third pitch. The above can be used to find the length of any size hipped skylight by first finding the rise to a foot for both hip and common (also jack) bars and then multiplying the base lines in ft. of the bars for a given size skylight by the figures obtained. The figures for one quarter pitch are 1.5 (or 1½) for the hips and 1.116 for jack and common. In the following will be shown a short rule for finding the length of bars of hipped skylights. Assuming that the lengths of the rafters are to be laid out for a skylight curb of which measures 4×6 feet and pitch of which is to be one-third, a plan of which is shown in Fig. 161, the short rule is applied as follows: As no ventilator is shown, deduct 48 from 72, which leaves 24 inches, the length of the ridge bar *d*. For the length of the common bar *a* divide 48 by 2, which gives 24 inches. Now add 3-16 inch for every inch thus found—namely, $24 \times 3\text{-}16 = \frac{72}{16}$, or 4½ inches, making the length of the common bar equal to 28½ inches. For the hip bar *c* add 9-16 for every inch, thus $24 \times 9\text{-}16 = \frac{216}{16}$, or 13½, making the length of the hip 37½ inches. It will be seen that the jack bars *b* are spaced 16 inches. To this add the same distance as in the common bar, $16 \times 3\text{-}16 = \frac{48}{16}$ or 3, making the length of the jack bar 19 inches. It is necessary to bear in mind in using this rule that one of the bends of the bar should meet the line of the curb, and on that line lay off the length obtained.

It may be naturally asked, if 3-16 and 9-16 inch are added for every inch in plan for the common, jack and hip bars, respectively, on one-third pitch, what would

be the amount to be added on one-quarter or one-fifth pitch? To answer this the diagram, Fig. 162, has been prepared, and which is drawn full size for a skylight having one-third pitch. As the term one-third pitch is taken from carpentry practice and means that the hight to the comb of a roof is one-third the length of the span, the altitude of a skylight of one-third pitch will be one-third of the width of the skylight. Draw A B equal to 1 inch, or half the width, and erect A C, which will be 2-3 inch, according to the explanation just made, and draw C B, which will be found to measure approximately 1 3-16 inches, or 3-16 inch more than the horizontal line A B. Therefore, 3-16 inch is added to every inch in plan for the common and jack bars. For the length of the hip draw D E F G, 1 inch square, and the diagonal D F, at right angles to which draw the line D H equal to 2-3 inch, and draw the line H F, which will measure 1 9-16 inches, from which ascertain that 9-16 inch is added for every inch in plan. This method is followed in getting the measurements for one-quarter and one-fifth pitch. For instance, with one-quarter pitch A C will equal ½ inch instead of 2-3 inch, and the other dimensions will change accordingly.

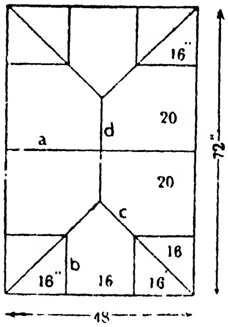


Fig. 161. Plan of Skylight

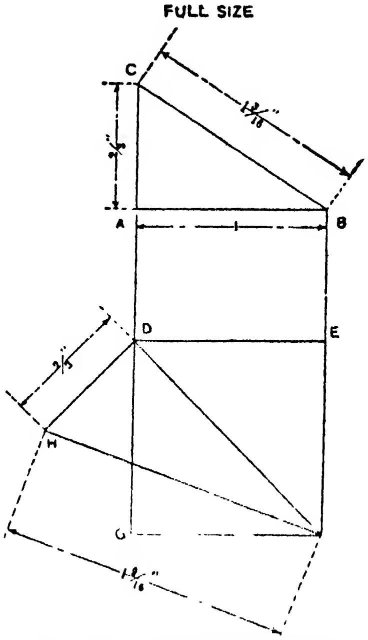


Fig. 162. Finding the Length of Skylight Rafters

Referring to Fig. 161, if a ventilator 6 inches wide was used, then 48 — 6=42 ÷2=21, to which the additions for the one-third pitch are made for every inch for common, jack and hip bar, respectively.

A PUTTYLESS SKYLIGHT

A method of constructing a puttyless skylight is shown by the accompanying drawings. Such a skylight has been designed to meet the demand for a cheap but absolutely strong and weather tight light and can be made advantageously in sizes

up to 3×3 ft. Being of simple construction, it can be made complete in three hours by a competent mechanic, including the work of laying in the glass and finishing the caps, as shown in Fig. 163.

If there is likely to be considerable call for these lights in various sizes, sheet metal stub patterns should be made for preservation, as per the accompanying sketches. The length of the bars is computed by the usual methods, except that as they do not come down on the glass rest of the curb the common bars are cut ½ in. and the hip bars ¾ in. less than measurements.

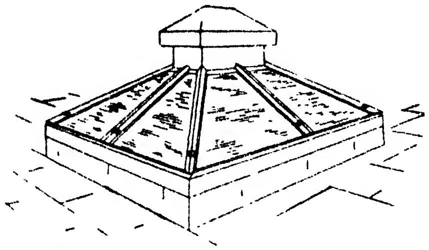


Fig. 163. A Puttyless Skylight

The vent neck is made in one piece, as shown in the isometric drawing. In bending this sheet it should be creased along the lines G H before being formed into the required shape. The corners should then be cut out at M, M, M, on all the three corners, and the sides of the neck pulled around until the corner A B meets the solder lap C.

The development of the patterns is the same as for any hipped skylight, an oblique section being necessary for the ascertaining of the true section of the bar and of the pattern. The principles of this method of developing are explained in the problem on page 67.

The procedure of assembling is to form the cut material to the required profiles; solder the two ends into the hood. The two supports, A, Fig. 165, are now soldered in position and the hood laid aside until the vent neck is soldered along lap C, Fig. 164, and kept square by soldering a small brace, bent similar to A of Fig. 165, cornerwise from one side to another, after which the hood is set on by soldering the neck to supports A, Fig. 164, with the hood on the bench and neck resting upside down on the supports.

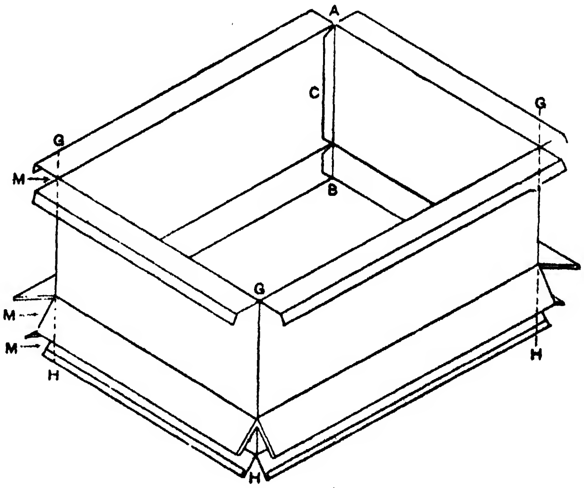


Fig. 164. The Vent Neck, Made in One Piece

The four sides of the curb are soldered together, being sure they are square; then the four common bars are soldered to the vent at T, Fig. 165, and set on the curb and the bars soldered to glass rest of curb R, Fig. 165. Next the hip bars are put in and tacked at R and S. The skylight is now turned upside down and

the common bars soldered at L and the hip bars at T. It is then ready to turn back and the glass laid on. The caps can now be set on and held by the copper cleat at the bottom and by soldering to the vent at S, thus completing the skylight.

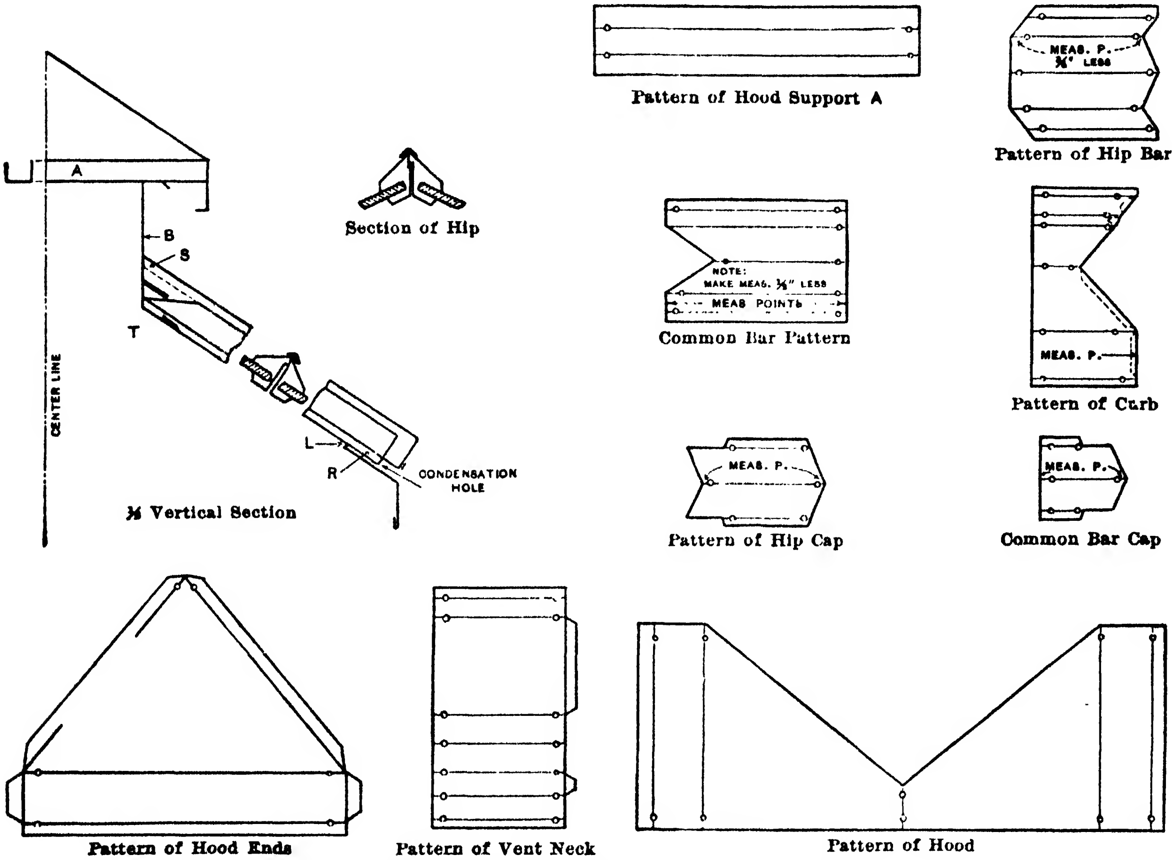


Fig. 165. Section of Skylight and Patterns

PATTERN FOR HIP BAR

The following deals with the easiest method of finding true profile and intersecting miter points, with curb and ventilator, of hip bar of a skylight, and also the method of obtaining the pattern for hip bar. In the accompanying illustration, Fig. 166, is shown a reduced reproduction of a hipped skylight. In this A B represents the center line, C the section of the curb and D the section of the ventilator and hood, the pitch of the skylight being one-third. In the section D of the ventilator the cap flange covering the glass was omitted, and it is suggested in constructing the skylight that a cap be formed on the ventilator to protect the joint between the ventilator and glass, as indicated in diagram X.

Place the profile of the common bar E in its proper position, as shown, and number each of the bends, as indicated from 1 to 6, on both sides. Where this bar E intersects the curb and ventilator, mark the intersections by similar numbers, as shown from 1 to 6 on the curb C; also from 1 to 6 on the ventilator D.

At pleasure from any point P on the center line A B draw a line at an angle of 45° (being the bisection of a right angle) and intersect it by a vertical line dropped from point 1 in the curb C at 1 in plan. Then P 1 represents the hip line in plan. Now, parallel to the pitch of the skylight in the sectional view draw any line, as *a b*, perpendicular to which project the widths of the various parts of the bar, as shown by similar numbers on *a b*. Take these projections on *a b* and place them in plan, at right angles to the hip line, being careful to have the points 1, 2, 4 come directly on the hip line P 1. Parallel to P 1 from the various numbers on *a b* draw lines until they intersect lines dropped from similar numbers in the curb C and ventilator D in the sectional view. A line traced through points thus obtained in plan, as shown from 1 to 6 in the curb and 1 to 6 in the ventilator will represent the intersections in plan between the hip bar and curb and ventilator.

Before the profile and pattern for the hip bar can be obtained, a true elevation of the hip bar must be constructed. Parallel to the hip line P 1 in plan draw any line, as F^1 G^1. From the intersections 1 to 6 in both curb and ventilator in plan erect lines indefinitely, perpendicular to P 1. Then, measuring from the line F G in the sectional view, take the vertical hights to points 1 to 6 in the curb C, as well as to points 1 to 6 in the ventilator D, and place them on similar lines erected from the plan, measuring in each instance from the line F^1 G^1. Draw lines between the curb and ventilator, as shown from 1 to 1, 2 to 2, etc., and if the miter lines at the curb and ventilator are true, the lines will all be parallel. This, then, completes the true elevation of the hip bar, showing the intersecting miter points between the hip bar and the curb and ventilator.

The profile of the hip bar is obtained by taking the projections on *a b* in plan and placing them at pleasure parallel to the hip bar in the true elevation, as shown by *a′ b′*. Perpendicular to this lines are erected intersecting similar lines and resulting in the profile of the hip bar H.

For the pattern for the hip bar take the girth of the bar H and place it on the line J K, drawn at right angles to the line of the hip bar. Through these small figures lines are drawn at right angles to J K and are intersected by lines drawn parallel to J K from similar numbered intersections in the miter lines of the curb and ventilator. A line traced through points thus obtained, as shown by L M N O, will be the pattern for the hip bar. If it is desired to notch out the bar so that

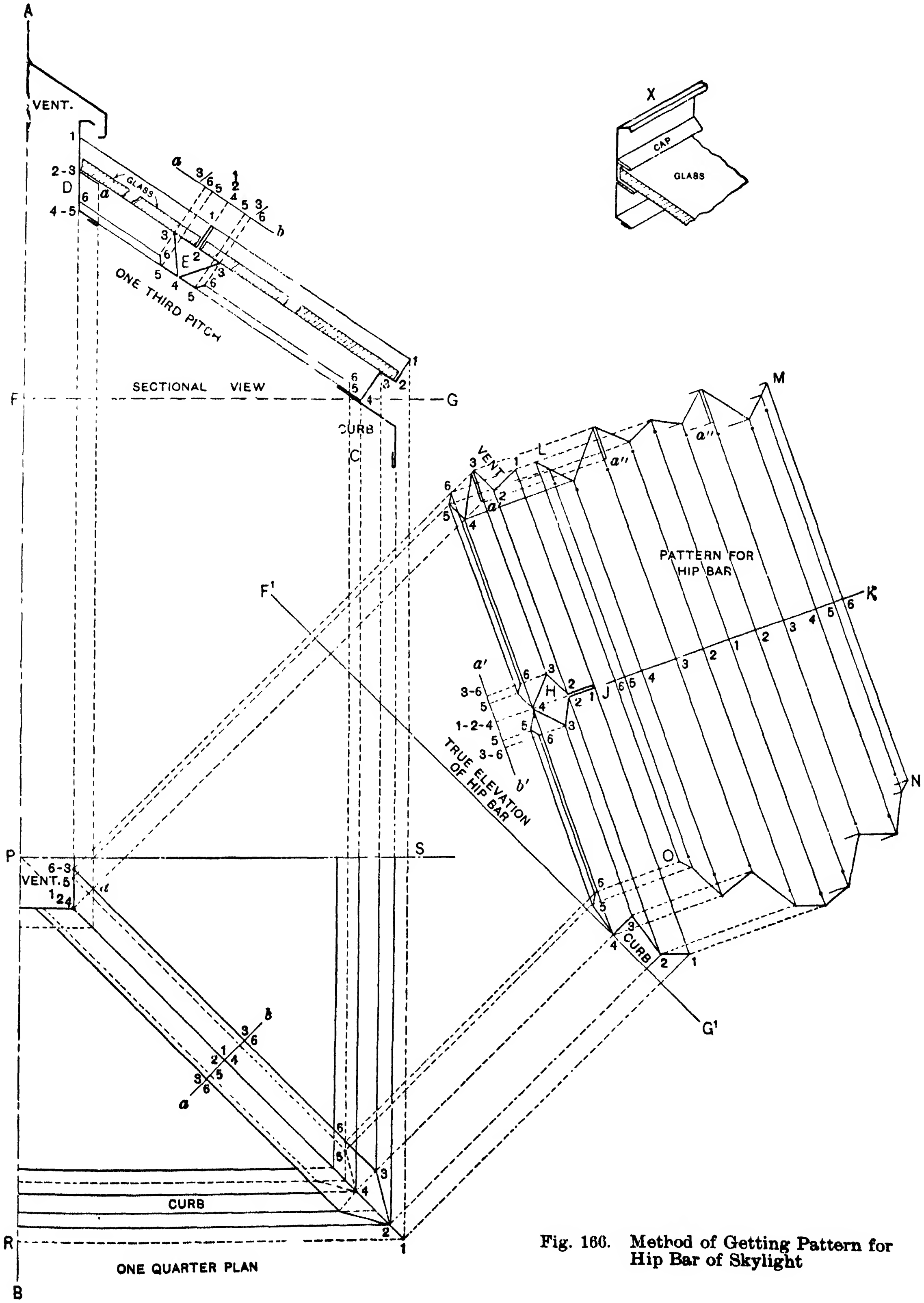


Fig. 166. Method of Getting Pattern for Hip Bar of Skylight

various hights to points 1^v to 6^v at the top of the bar and place them on similar numbered lines, erected from the plan, in the true elevation of the hip bar, measuring in each instance from the line C° D°, thus obtaining the points of intersections 1^v to 6^v. In similar manner obtain the vertical distances from the line C D in the sectional view to points 1 to 6 in the curb, measuring above and below the line C D as required and place them on similar lines erected from the plan in the true elevation measuring above and below the line C° D°, and obtaining the points 1 to 6. Connect lines between the points 1 to 6 and 1^v to 6^v, which gives the true elevation of the hip bar on 1 K in plan.

The profile of the hip bar is obtained by taking the projections of the bar E in the sectional view on the line *a b* and placing them on the line *a b* drawn parallel to the line of the hip in the true elevation. From the small figures on *a b* and perpendicular to same, erect lines intersecting similar lines in the true elevation from 6 to 1 to 6. Connect the lines and then will E° be the true profile or the hip bar.

For the pattern for the hip bar take the girth of the profile E° and place it on the line N O drawn at right angles to the lines of the hip bar as shown by similar figures. Through these small figures at right angles to N O draw lines, which intersect by others at right angles to the lines of the hip from similar numbered intersections 1^v to 6^v at the top and 1 to 6 at the bottom. A line traced through points thus obtained will be the pattern for the hip bar.

Before the pattern for the jack bar can be formed the miter line between the jack and hip must be obtained both in elevation and plan as follows: Take the projections of the bar E in the sectional view on the line *a b* and place it at right angles to the jack bar M in the plan as shown by similar numbers on *a b*, being careful that the distance from the corner of the curb line *h* to the center of the jack bar M has the required dimension. Then parallel to the jack bar M, through the small figures on *a b* lines are drawn until they intersect similar numbered lines on one side of the hip bar J, thus forming the miter line of the short cut from 1 to 6, also the miter line of the long cut from 1 to 6°. From the intersections on this long and short miter cut at right angles to the lines of the jack bar M, lines are erected to the sectional view intersecting similar numbered lines from the profile of the common and jack bar E, obtaining respectively the miter line of the short cut shown by 1, 2, 3, 4, 5 and 6, and of the long cut shown by 1, 2, 3°, 4, 5° and 6°.

For the pattern for the jack bar take the girth of the profile E and place it on the line R S drawn at right angles to 1 1^v. Through the small figures on R S parallel to 1 1^v draw lines, which intersect by others drawn parallel to R S from

similar numbered intersections on the curb, and the miter lines 1 to 4 and 1 to 6°. A line traced through points thus obtained will be the pattern for the jack bar. T U will be the cut against the curb, P V the short cut against the hip and V W the long cut. The jack bars must be formed right and left. The pattern for the curb is obtained from the plan in the usual manner.

VALLEYS IN SKYLIGHT CONSTRUCTION

A *Metal Worker* took exception to the demonstration, or rather the design, of the method of obtaining the pattern for a valley, which is presented elsewhere in the book. The remarks coming from an experienced man and well taken, are here reprinted:

Some time ago you explained how to lay out a skylight with a valley bar as shown in Fig. 169. In my opinion a bar is impractical. Even with extraordinary

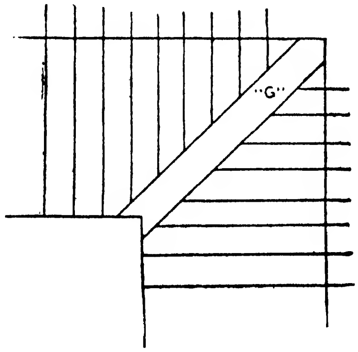


Fig. 168

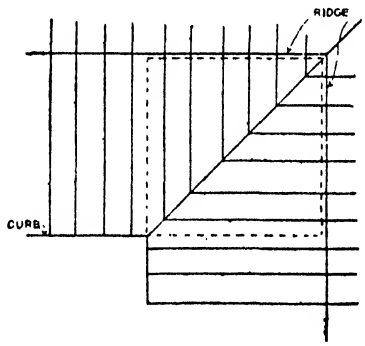


Fig. 169

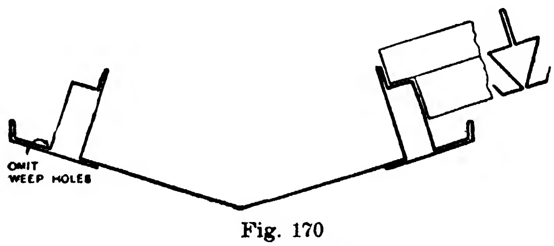


Fig. 170
Suggestion for a Skylight Valley.

care in glazing it is apt to leak, for it is self-evident that the valley carries off the water from part of the skylight within the dotted lines of Fig. 169. No experienced roofer would finish his standing seams in this manner. He would put a flat strip, G, Fig. 168, in the valley, thereby giving the water a smooth and watertight path. Now why not do this in constructing a skylight with a valley?

Fig. 170 shows what I consider a practical method of making a valley bar, or more correctly a valley curb. This is just a suggestion, and is, no doubt, susceptible of modification, retaining though, the essential feature—a smooth path for the flow of the water.

PATTERN FOR A VALLEY BAR

To obtain the pattern for a valley bar in a skylight having one-third pitch as shown in Fig. 171, the following rule is applicable to any case, regardless of the pitch used:

Therefore, in Fig. 171 assume that A B C represent a section of one-half of a skylight having one-third pitch. Complete the section of the curb, as shown by *a b c* and the ridge bar *d e*. In its proper position place the profile of the common bar, as shown by D. Number the corners of the profile, as shown by the small figures 1 to 6 on both sides, through which, parallel to A B, draw lines intersecting the curb *a b c* at points from 1 to 6 (the points 4, 5, 6 representing the outlet of the condensation gutter) and the ridge bar *d e* from 1 to 6. In its proper position, in line with the section, draw the part plan E F G J H and the valley line 1 1 at an angle of 45 degrees.

Take a tracing of the profile D in section and place it in a position shown by D^1. Through the various bends on one side of the profile D^1, as from 1^v to 6^v, draw lines parallel to the valley line 1 1, which intersect by lines drawn at right angles to C B in section from similar numbered points of intersections in the curb *a b* and the ridge *d e*. Through points thus obtained trace a line in plan, as shown from 1 to 6, at bottom and top, which represent respectively the miter line in plan between the half bar and the curb and ridge. Trace the miter lines opposite the line 1 1 at both ends, as shown, which completes the plan view between the valley bar and curb and ridge. It should be understood that the profile D^1 in plan is not the true profile, but is only placed in that position to give the horizontal distances.

The next step is to construct a diagonal section, from which the true profile and pattern are obtained. Parallel to 1 4 in plan, draw C^1 B^1. At right angles to C^1 B^1, and from the various intersections 1 to 6 on the ridge and curb lines in plan, erect lines crossing it. Now, measuring in each instance from C B in section, take the various vertical distances to points 1 to 6, both in the curb *a b* and ridge *d e*, and place them on similar vertical lines in the diagonal section, measuring in each case from C^1 B^1. Through these intersections draw lines, as shown

from 1° to 6 at both top and bottom, which represent respectively the miter lines of the bar between the ridge and curb.

For the true profile of the valley bar take a tracing of the profile D or D^1 and place it at right angles to 4 4 in diagonal section, as shown by D^2. At right angles to 4 4 from the various intersections in D^2 draw lines, intersecting similar numbered lines previously drawn. Connect the various points as shown by 6′ to

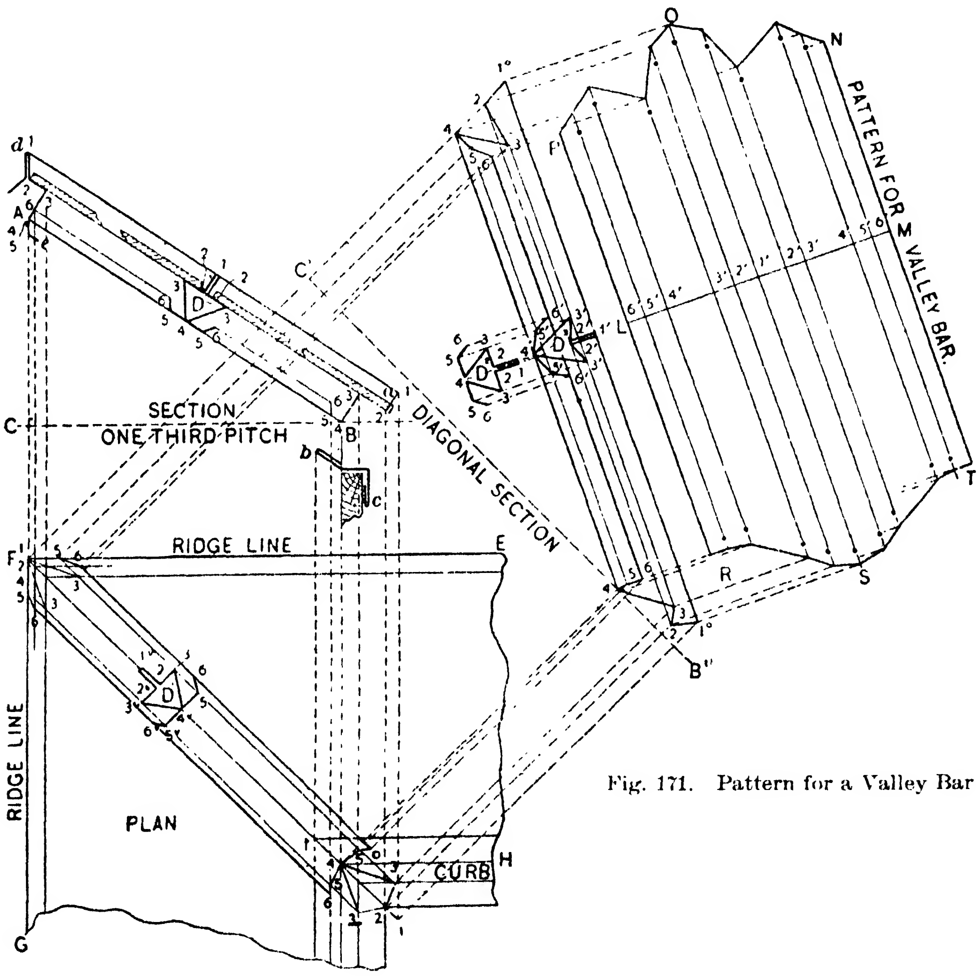


Fig. 171. Pattern for a Valley Bar

1′ to 6′ or D^3, which is the true profile of the valley bar. Take the stretchout of D^3 and place it on the line L M drawn at right angles to 1° 1°. At right angles to L M and through the small figures draw lines, which intersect with lines drawn at right angles to 1° 1° from similar numbered intersections in the miter lines at top and bottom. A line drawn through points thus obtained, as shown by N O P R S T, will be the pattern for the valley bar.

A FEW POINTS ON SKYLIGHTS

Next to keeping out rain, the most important feature of skylight construction is the provision for taking care of the condensation, which it is impossible to prevent whenever the temperature outside of the building is relatively low and inside comparatively high. While practically all skylight makers provide condensation gutters on all bars and curbs, many often neglect, or overlook, certain details in making connections that result in condensation leaks.

When a skylight with the tubeless closed curb formation, indicated in Fig. 172, is so large as to require assembling on its curb at the building, it often happens that seams or miters are left unsoldered, from *a* to *b* on the under surface of the curb, owing to their apparent inaccessibility. This allows the condensation or

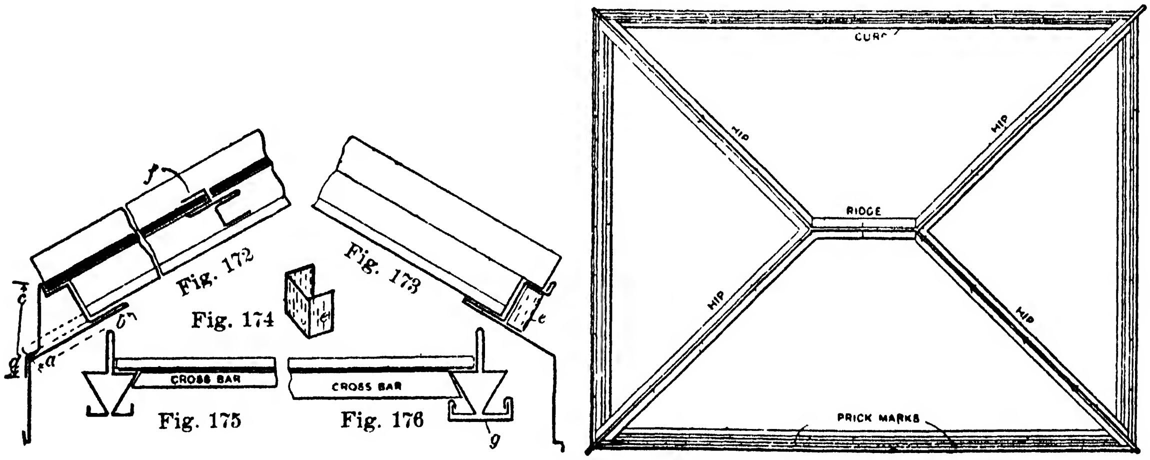


Fig. 177

A Few Points on Skylights

leakage delivered from the bar gutter into the curb gutter to flow through this unsoldered portion down behind the flashing into the building. This is especially so when the curb is partly filled with ice, or is coated with ice on the outside, as the water thus dammed inside the curb is forced to find and flow through any possible outlet. The best way to avoid this imperfection is to conduct the water through the curb by means of tubes, as indicated by the dotted lines, instead of depending upon holes punched in the curb; and when access to the under surface of the curb cannot be otherwise had, to expose the seam *a b* by bending back the portion *c d* on each side of the seam or miter, leaving the interior of the curb open for access with the soldering copper. After *a b* has been soldered, *c d* is bent back into its proper place and soldered.

A curb of the open formation, shown in Fig. 173, is superior in every way to the closed formation, shown in Fig. 172, as the liability to leakage from unsoldered seams, as well as from filling, freezing and bursting, is avoided. It is also cheaper to make. In large and comparatively flat skylights, the open curb can be strengthened by soldering a clip, *e*, edgewise under the end of each bar, the shape of the clip *e* being shown in Fig. 174.

In Fig. 172 *f* represents a cross bar, used to join the ends of two lights of glass when the distance from the curb to the ridge is too great to admit of the use of a single light. A common fault is shown in Fig. 175—namely, the failure of the condensation gutters of the cross bar to overlap the edge, or flow into the condensation gutter of the main bars, which, of course, causes a leak. This fault is avoided by making the depth of the cross bar such that its gutter will rest on the edge of the main bar gutter, as shown in Fig. 176, thus making it possible to overlap into the same, which is not possible when the cross bar is made too shallow, as shown in Fig. 175. The ends of the cross bar gutter should be turned slightly downward with a pair of pliers, so that the water will be sure to drop off into the main bar gutter, as otherwise it would sometimes follow back under the cross bar and drip off into the building. This edge, of course, should not be bent down so far as to interfere with the flow of the water from above the cross bar.

The bottomless bar section, shown in Fig. 175, serves very well for pitches of, say, 5 in 12 inches and steeper, but for flatter pitches an extra bottom or gutter-piece, *g*, should be used, as shown in the bar section of Fig. 176, in order to prevent the dripping of the condensation which forms inside of the hollow bar, which would give the impression that the skylight itself leaked.

It is a common practice in getting out skylights to simply shear out, measure the lengths, cut the miters and form up the curb, hip and ridge, leaving the workman who assembles the skylight to measure off and mark the bar spacing on the same. But it was found that it pays, after cutting the members ready for forming, to strike the glass line of each with the straight edge, and measure and prick the bar spacing thereon. This measuring can be done much quicker by the cutter while the work is on his bench in the flat than by the section workman after the work has been formed and transferred to his bench. The curb, hips and ridge of a skylight are shown in Fig. 177, assembled and ready for the bars, the spacing of the same having been pricked in before forming. This is not only cheaper but more accurate than after measuring. This method is especially advantageous when making a number of similar skylights, as the spacing is simply pricked from the patterns during the cutting operation.

HIP SKYLIGHTS WITH DIFFERENT PITCHES

A request was received from a correspondent, for the exemplification of the method of obtaining the patterns of a skylight, with ends having a pitch of 8 in. to 1 ft. and the sides having a pitch of 6 in. to 1 ft. A solution of the problem is given in the following:

Many types of bars, curbs and ventilators abound in the sheet metal industry, and as the sections as here shown are extensively employed, they are selected for this exposition; that is, the bar in elevation on line of arrow N; curb E, ventilator neck B, and ventilator hood Q are assumed as being standard, or the given profiles of the correspondent. Draw a horizontal line 12 in. long, Fig. 178, and erect a vertical line 6 in. long and complete the triangle by drawing the hypotenuse. This triangle 7 *a′* 15 represents the pitch of the sides, and as it is customary, to facilitate measuring, to use the glass line, the hypotenuse will be such. Likewise, the apron of the curb lies in the same vertical plane, for it gives the same curb measurement for the glass measurement. (See Fig. 180).

Construct the given profile of the bar with its glass rests or shoulders, on the pitch line as indicated by 0 to 10. Cause lines to pass through these points parallel to the pitch line. On the altitude of the triangle place the given profile of the neck B with its glass rest on the pitch line, also the hood with the sheet metal support T of elevation M. At the intersection of the base line and hypotenuse place the given profile of the curb E, with its glass line also on the pitch line. To the right draw another horizontal 12-in. line coincident with the base of the first triangle and erect an 8-in. altitude. Complete the triangle. Project a line from the joining point of the altitude and hypotenuse of the first triangle, and where it cuts the hypotenuse of the second triangle drop a vertical line as shown by 7, 15 *a* of elevation M, giving the pitch triangles of the ends.

Lines 200 201 and 203 204 are adjuncts in the scheme of projection as here used. Drop a line from the point 7 of elevation N, profile E, indefinitely and continue the altitude line downwards. In elevation M these lines terminate on line 200 201 and are swung around to line 203 204 from point 203, thence are drawn horizontally, realizing a rectangular figure in *a b* 7 *d* in the plan, *a b* being the pitch triangle of elevation M, and *a d* the pitch triangle of elevation N. A diagonal line of this rectangle from *a* to 7 will be the plan of the pitch triangle of the hip bar and one of the lines of the hip bar. Incidentally this is the miter line of the curbs and necks. Drop lines from the curb and neck of elevation N to this miter line and continue them across it for a

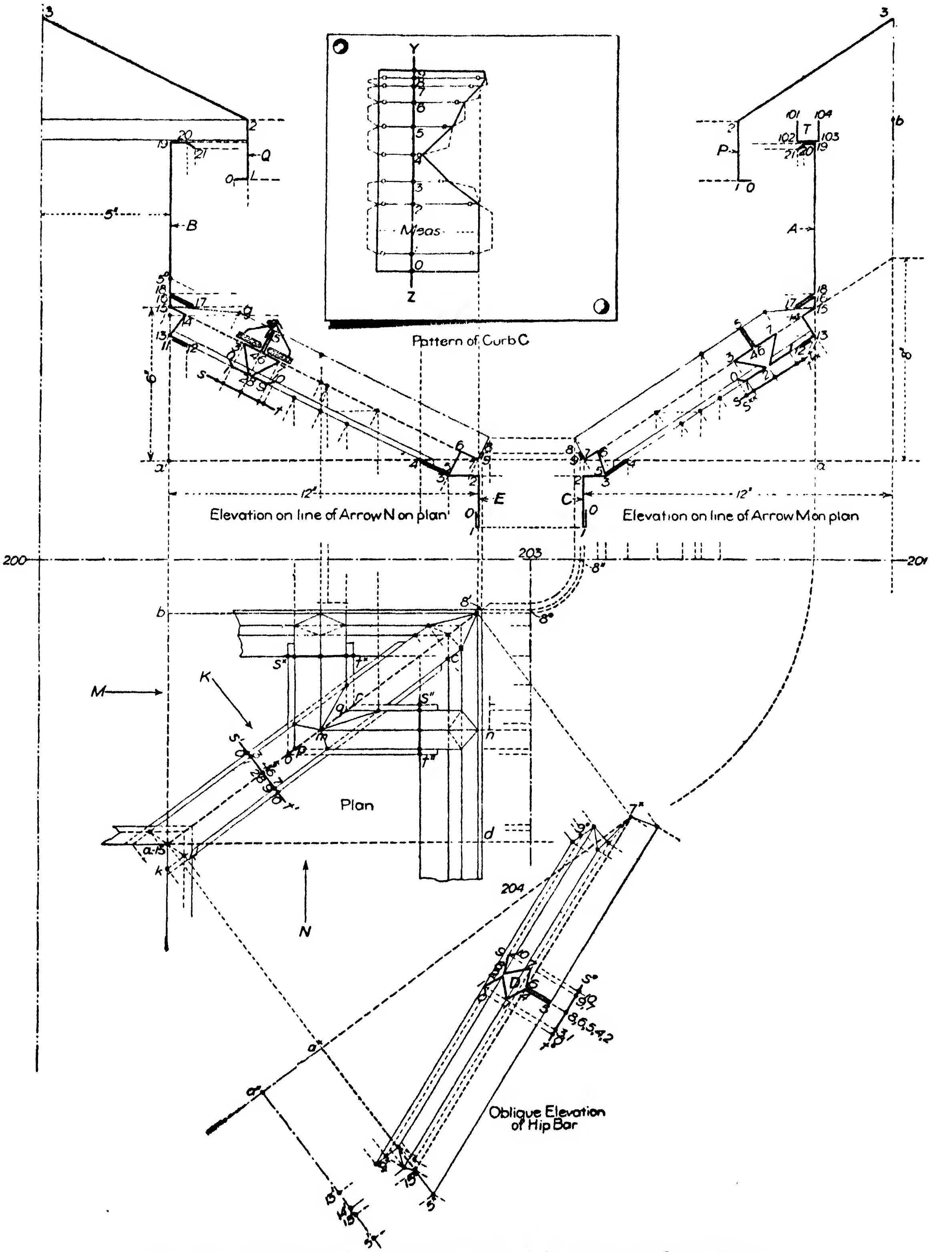


Fig. 178. Method of Developing Bars, Curbs, Vent and Hood of Skylight

short distance to delineate a plan view of these profiles. At the crossings of these lines with the miter line, lines are drawn to line 203 204, thence around to line 200 201 and upwards in the elevation M, intersecting them with like numbered lines from elevation N; as 8 of curb E is dropped to 8′ and carried to 8° to line 200 201 8″ and then upwards until it meets the horizontal line projected from 8 in elevation N, thus establishing point 8 in elevation M. This process of projection modifies the profiles of the curb and neck in elevation M as indicated by C and A. The ascertaining of the changed profile of the bar for elevation M is held in abeyance for the completion of the plan view of the jack bars.

Transfer the widths of the profile of the bar on line *s t* of elevation N and place it as shown by *s′* and *t′* in the plan. Through these points parallel to *a* 7 draw lines, stopping where these lines meet the curb and neck lines; like the line passing through 7 9 of *s′ t′* (representing two lines of the hip bar) will terminate at *k k′* and *l′ l*, etc., etc.

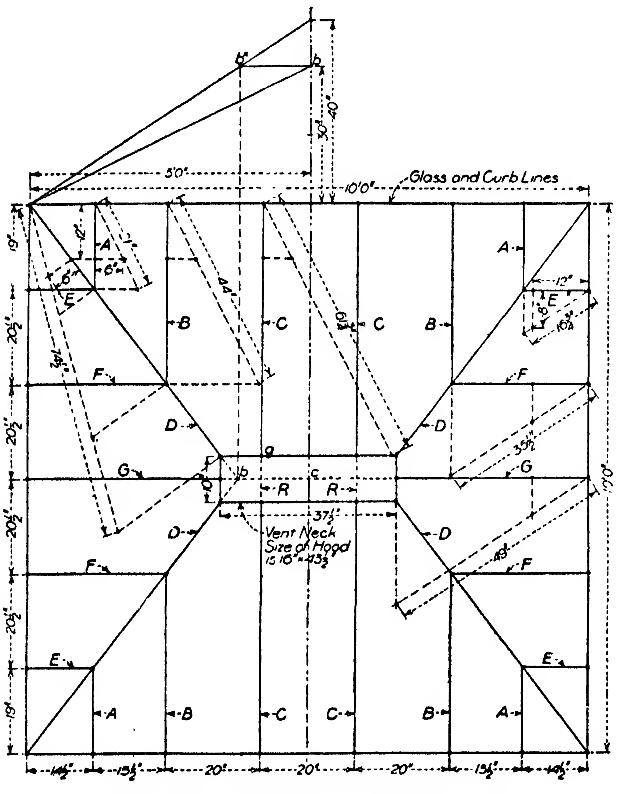


Fig. 180. Scale Lay-out of Skylight

For the plan view of the jack bars transfer *s t* to one of the lines of curb as *s″ t″* and draw horizontal lines through the points meeting the hip bar at *m* and the curb at *n* as shown. From *m* erect a vertical line, also from *o*, *p*, *q*, *r*, which will be the jack bar for the 8-in. pitch; and line s^x t^x will be the width. Carry s^x t^x to elevation M or s^{xx} t^{xx}, and project lines to their respective lines parallel to the pitch line, acquiring the changed profile of the jacks and common bars of the 8-in. pitch. For the elevations of the jack bars necessary to obtain the patterns, lines are projected upward to the elevation N from the points *o*, *p*, *m*, *q*, *r*, and to line 203 204 to line 200 201 and upward of elevation M. Then will the dotted lines and points indicate the intersection of the jacks with the hips in elevation.

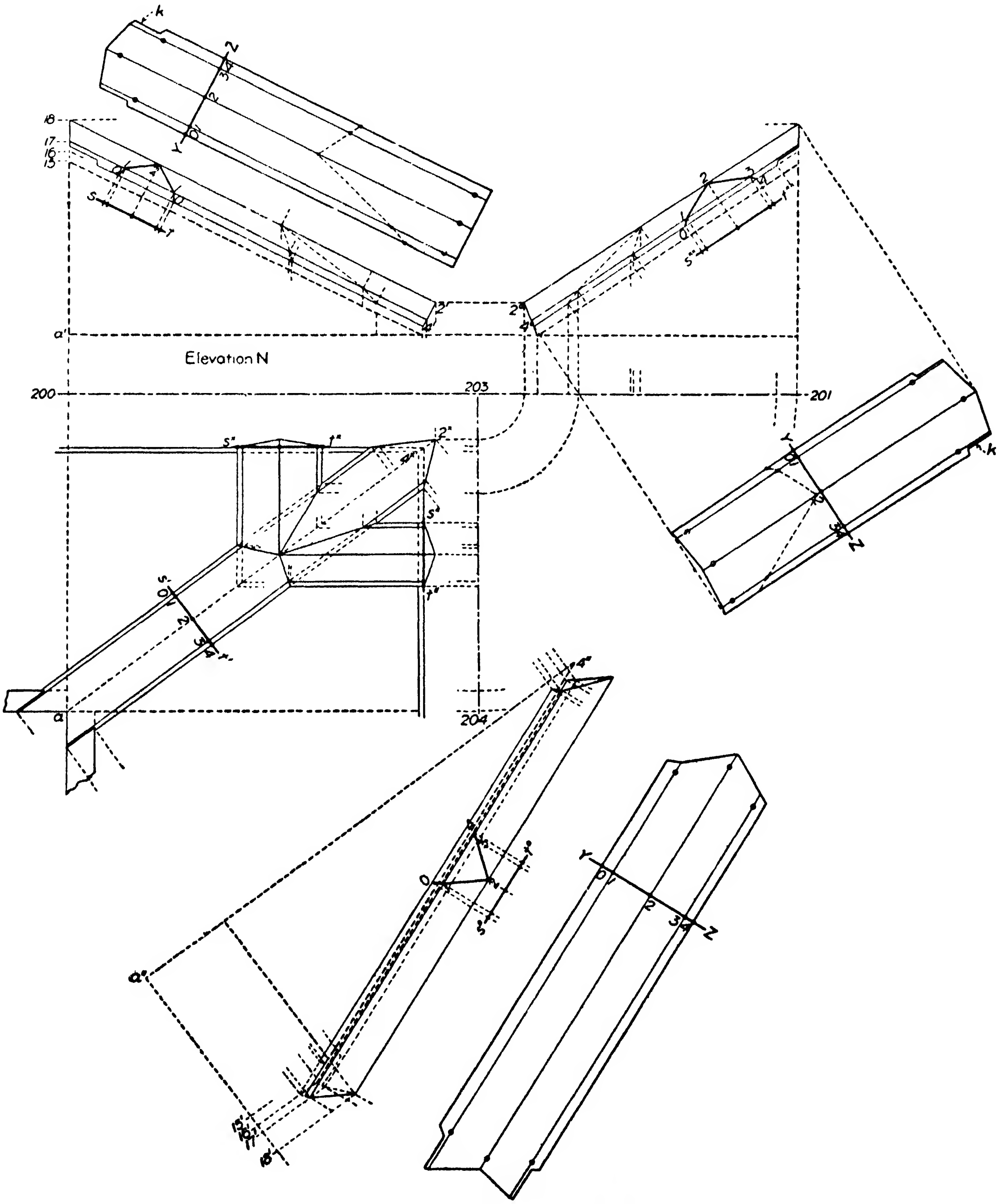


Fig. 179 Method of Developing Caps

For the acquisition of the patterns of the hip bar and its true profile a view is requisite, in which the true lengths of the hip bar are shown. Such a view will be oblique and will be one of the plan seen on the line of the arrow K; in other words, the pitch triangle of the hip bar is to be found. Therefore, project lines

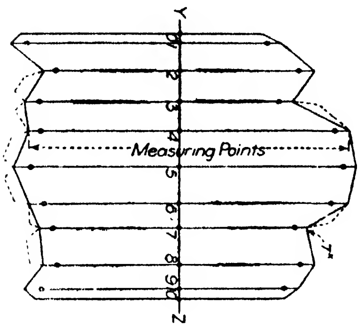


Fig. 181. Pattern of Hip Bar

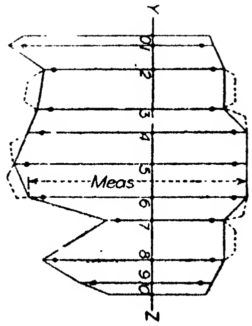


Fig. 182. Pattern of Jack Bars A and B, Fig. 180

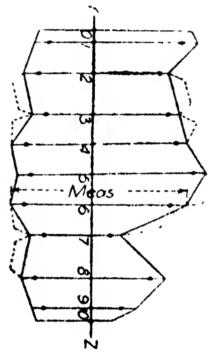


Fig. 183. Pattern of Jack Bars E and F, Fig. 180

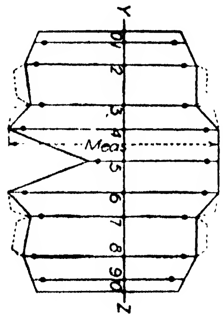


Fig. 184. Pattern of Common Bar C, Fig. 180

Patterns for Hip Bars, Jack Bars and Common Bars

indefinitely from a and 7 and parallel to a and 7 draw a line, stopping at 7^x, but crossing for a short distance at a^x. This will be the base line of the triangle. To one side of a a^x draw a parallel line with the various hights of elevation N, as a'' to $13'$ $14'$ $15'$ 5. At right angle to this line project lines towards a^x 5^x. From 15^x to 7^x draw the hypotenuse, thereby establishing the pitch triangle of the hip bar, all as shown in the illustrations.

Where similarly marked lines from a'' to $5'$ intersect those projected from the plan, as, for instance, a line from k (representing point 9 of s' t'), crossing $13'$ locates point 9^x, etc., etc. From the points thus located, and parallel to 15^x 7^x, draw lines terminating where they meet the lines from the plan, as a line from l (representing 9 of s' t') meeting a line from 9^x establishes point 9°.

For the true profile of the hip bar place s t, elevation N, at s° t°. Projectors to correct lines, as 9 to line 9^x 9°, locates point 9. Be careful here to keep the numbers on the right side.

The development of the pattern is by the parallel method. Owing to the restriction of space they are drawn separately, just as would be done in shop practice, and the stub patterns like these preserved for future use, inasmuch as they can be applied to various sizes of skylights with these pitches. These patterns are cut by tacking a piece of drawing paper near to views which give true lengths, as shown by pattern for curb C of Fig. 178. An inspection of Fig. 179 should show the process, for with the developing of the caps there are more room and less lines to

confuse. Therefore, on the piece of drawing paper, Fig. 181, and at right angles to line $15^x\ 7^x$ draw line Y Z, Fig. 181. (All stretchout lines will be so designated.) On this line prick off the stretchout of profile D and from points in the oblique elevation to similarly numbered lines in the stretchout locate the points for the

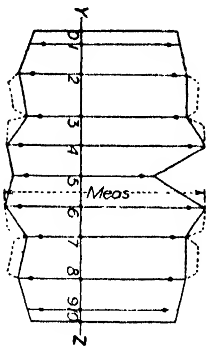


Fig. 185. Pattern of Common Bar G, Fig. 180

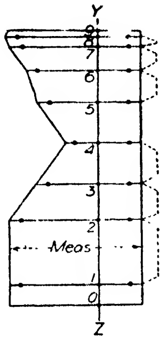


Fig. 186. Pattern of Curb E, Fig. 178

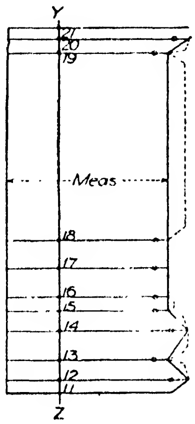


Fig. 187. One-Half Pattern of Vent Neck A, Fig. 178

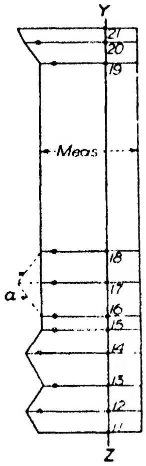


Fig. 188. Pattern of Neck B, Fig. 178

Pattern for Common Bar, Curb and Vent Neck

pattern—to wit, a projector from 7^x defines point 7^x in the pattern. Repeat this procedure for the patterns of the common and jack bars, Figs. 182, 183, 184 and 185. Attention is called to the cutting of the vertical members of the common bars at *g* 15, Fig. 178. This in no way lessens the strength of the bar and saves a lot of notching. For by doing this, the glass rests of both the neck and the hip bar are accessible for the point of the soldering copper.

For the patterns of the curb E and C, Fig. 178, and necks B and A one could develop parallel from the plan views. The procedure here used and identical to this and recommended, is to place the stretchout line Y Z with the girth of curb *c* at right angle to *a*′ of elevation N, and project lines from the points of curb E. For curb E the points are projected from curb C to the stretchout of curb E. Repeat this for the necks. Note how the glass cover is cut away at *a* of pattern for B, Fig. 188. This will be covered by the caps and is done to facilitate assembling.

A skylight with two pitches will always have a ventilator with two sides longer than the ends, and it is assumed that the vent will be 10 in. wide. Therefore pattern of neck A is one-half, Fig. 187, the other pattern being of a size as called for by Fig. 180. This holds true for the hood, the end *P* remaining as it is for all

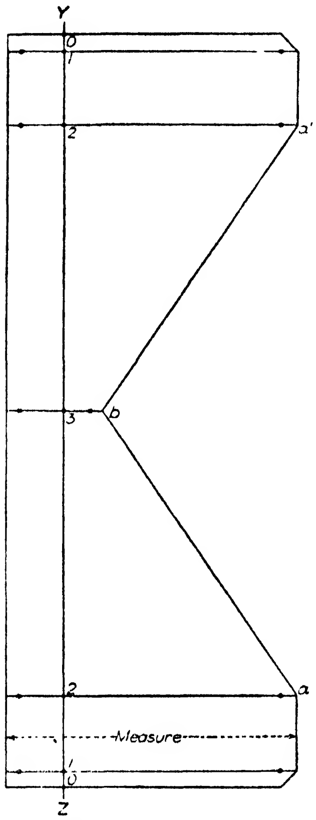


Fig. 189. Pattern of Hood Q, Fig. 178

10-in. vents, Fig. 190, and the pattern of Q, Fig. 189, being of a length as required. For the hood pattern place the stretchout of P under Q, and for Q under P. That is, the cut of pattern of Q as shown by *a b a'*, is as deep at 2 *b* of elevation M. The sheet metal support T is made of heavy gauge and the pattern is as shown. This is first soldered to the hood, then to the neck. The number of these depends on the size of the vent. Band iron braces bolted to the hood and vent would make a good substitute. If the vent is long it is well to stiffen with suitable braces at the point of thrust of the bars, as *g* of Fig. 180. These braces are indicated by dotted lines.

Laps are allowed on all patterns, as per instructions of dotted lines. Though here shown in their exact place, for sheet metal stub patterns for preservation the stubs would be cut net and the laps indicated by the acid-marking fluid on the inside of the pattern cut.

For the patterns of the caps redraw the three elevations and the plan of the pitch triangles, Fig. 179. Place the profile in elevation N of the cap and in the true position relative to the profile of the bar in elevation N of Fig. 178. Complete the views and develop the pattern as per former instructions. Attention is called to the notching of the caps at *k* to fit over the glass cover of the necks.

The layout of a 10 × 10-ft. skylight is shown in Fig. 180 and is as follows: To any convenient scale draw a plan of the skylight. Continue the center line of any two sides; and as one-half of 10 ft. is 5 ft. and two sides have a pitch of 8 in. to 1 ft., place a point 40 in. on the center line from the side as shown. As the other two sides have a 6-in. pitch, place a point 30 in. from the side. Draw lines to the corner. Then will these two lines indicate the pitches. Without going into a geometrical explanation of why, it is stated that a line parallel to the base line of these triangles is projected from *b* to the hypotenuse of the 8-in. pitch, as b^x, then dropped to the center line of the other two sides, determining the location of the apex of the hips, D. Since the ventilator is 10 in. wide, lines parallel to *b c* and on both sides 5 in. away are drawn to the hips. Scaling this it is found that the sides of the ventilator neck will be 37½ in.; hence as the hood is 6 in. larger it will be as stated on the layout.

The maximum width of glass that ought to be used is 24 in., and though some prefer a width of 18 in. the choice is here for 20 in., necessitating the spacing of bars 20½ in. By a little experimenting with this layout it was learned that by having the 20-in. glass on the ends (6-in. pitch) a layout for the bars, such as

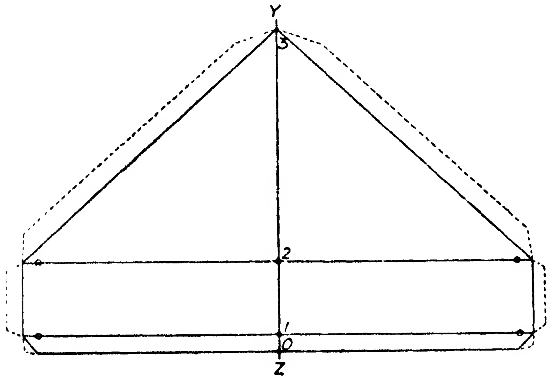


Fig. 190. Full Pattern of Hood Ends P, Fig. 178

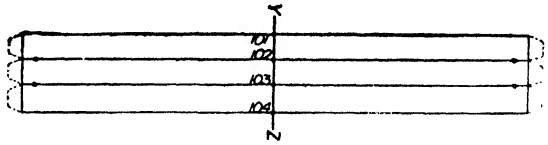


Fig. 191. Hood Support T, Fig. 178

shown resulted. It is to be understood that appearance rather than exact glass sizes influenced this layout.

The length of the bars was found by scaling; which was nothing more or less than placing the pitch triangles on the bars, knowing that they were the bases and that the scaling of the hypotenuses would give the lengths of the bars.

The profiles of the bars are of ample strength for a skylight of this size if, say, 24-gauge of galvanized sheet steel is used; still, it would not be a waste of material to reinforce the hips with a core plate of about 18-gauge material.

In conclusion, it is desired to say that if the development of the patterns is for a shop equipped with multiple dies and a drop brake, the standard type of bar should be used, as required by the dies, throughout. This could only be accomplished by an empirical manipulation of the pre-stated process, resulting in discrepancies in the pattern cuts, in no way serious, inasmuch as an error of 1-16 in. is allowable in skylight work. There would be little or no trouble assembling, and about the only serious fault would be the appearance of the jack bars. They would be of the same width, and would present a ragged appearance where joined to the hips.

ERECTING LARGE HIPPED SKYLIGHTS

The interesting feature of the work on a large reinforced concrete warehouse is the way the large skylights were set on the elevator towers. Owing to their size,

13×15 ft. for the larger one, they could not be assembled in the shop and hoisted to the roof. They were therefore shipped to the building as they came from the brake, excepting that the seams of the gutters were made in the shop and the vents were assembled.

As it was easier to assemble these lights on the large flat main roof, where they could be turned about at pleasure, rather than when they were in place on the towers, the skylights were built by the usual mode of procedure, as indicated in Figs. 192 and 193. Fig. 192 shows the skylights in the relative position they will

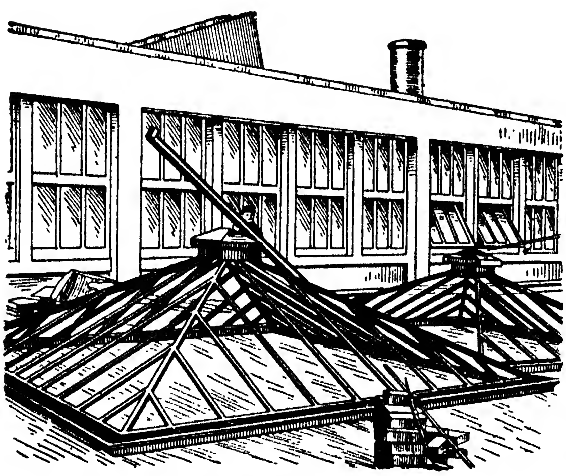


Fig. 192. Skylights for the Towers

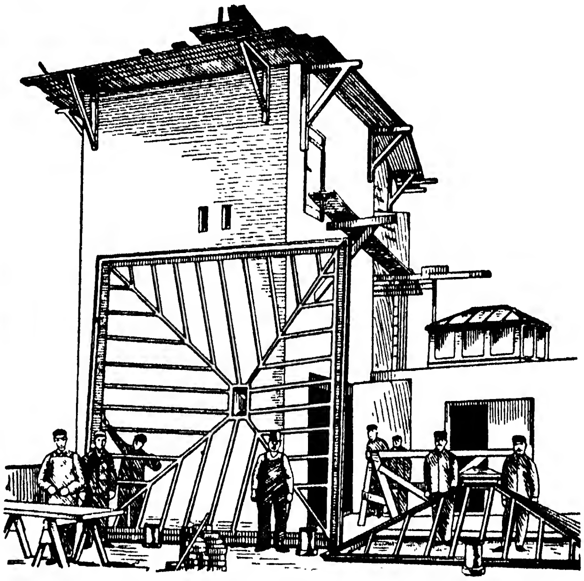


Fig. 193. Skylights Placed for Soldering Bars

occupy on the towers. As the curb of the smaller light was integral to that of the larger one and as it was desirable to raise each one separately to the towers, the bars of the smaller one were left out of the side adjoining the larger one. These bars will, of course, be soldered in when the skylights are on the towers. The workman in this picture was not working on the skylight, but had just come out of the temporary shop inside, where he had made the leader he is carrying to place on the roof. This picture also shows how the hollow galvanized sheet steel windows pivot.

Fig. 193 shows one of the positions the men placed the skylight in to permit them to solder with facility the laps on the bars. In some of the positions of the skylight it was away from the wall and held by means of long pieces of handy sticks of wood. In raising the skylight it is placed against the tower, but turned with the bars out instead of in, as it now is, and the curb which will go to the farther side of the tower will be on top, so that the skylight will need no turning after it is on top of the tower.

To raise the skylight a rope will be tied to each side and two men standing on the scaffolding, four men in all, will pull it up, exercising due care in the landing of it to guard against collapse, for at one time all the weight will be on the center of the skylight. From the scaffolding the men will glaze and cap the two skylights, and it is to be understood that the smaller light which goes to the tower on the other side will be raised first.

The glass for the skylight over the elevators, three in all, will be of plain glass, protected by wire screens conforming to the fire underwriters' rules.

A REINFORCED HIP TURRET SKYLIGHT

In the following description of the typical construction of a hip turret skylight no dimensions are given, as the members must necessarily vary according to the areas covered and the lengths of span in different skylights.

In the accompanying sketches, Fig. 194 is a vertical cross section; Fig. 195 a vertical section of turret, showing stationary glass in ends; Fig. 196 a horizontal section on A A of Fig. 194, and Fig. 197 a plan view of the structural skylight roof framing. Referring to Fig. 194, *a* is the terra cotta filled angle iron roof curb, upon which the turret of the skylight rests, the typical construction of which is too well known to require description. This curb is generally, although not always, furnished by the building contractor, and is sometimes made of reinforced concrete or brick, depending upon the nature of the area lighted, wood construction, naturally not entering this discussion of a type of skylight, which is entirely for fireproof buildings where wood is but little used.

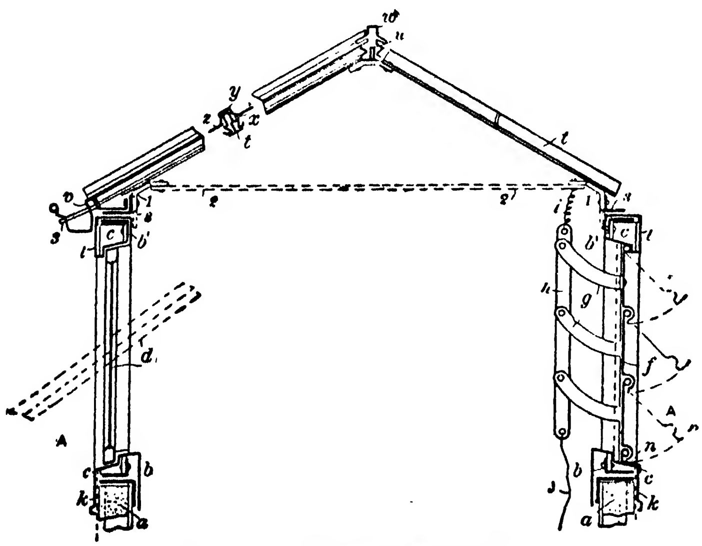


Fig. 194. Vertical Cross Section

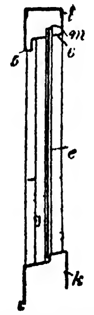


Fig. 195. Vertical Section of Turret

The angle iron framing of the turret consists of horizontal angles *b* and *b'* around all four sides of the opening, joined by the uprights *c*. The corner uprights are made of angle shape, so as to also act as knees for securing the miter connections of the horizontal angles *b* and *b'*, while the other uprights are made of T-shape in order to allow of a small and symmetrical section in the sheet metal posts in which they are incased. In Figs. 194 and 196 *d* indicates pivoted sashes, in Fig. 196 *e* the stationary glass, in Figs. 194 and 196 *f* the movable louvres, *g* the lower operating arms and *h* the bar connecting those arms for operating all louvres simultaneously. *i* in Fig. 194 is a spring which keeps the louvres closed and J a cord for pulling them open.

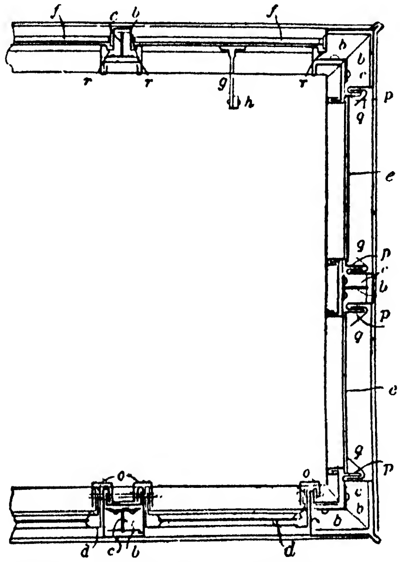


Fig. 196. Horizontal Section on A A

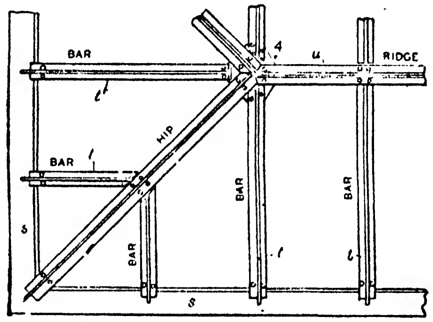


Fig. 197. Plan View of Skylight

It is to be understood that, the conventional operating devises of gearing for turret sashes, illustrated on page 44, can be employed to open and close these louvres.

The lower sheet metal curb *k* and the upper curb *l* of the turret run continuously around all four sides, without change of profile, unless it is desired to use stationary glass in the ends, in which case the glass groove *m* in Fig. 195 is formed in the end pieces of curb *l*.

The small piece *n* is planted on curb *k* to receive the lower edge of the lower louvre. Curb *k* is wider than curb *l*, the surplus projecting inward and being formed with a wash, so as to catch and conduct to the outside any leakage or condensation occurring inside of the skylight or turret not otherwise taken care of.

Referring to Fig. 196, it will be seen that the upright sheet metal posts in connection with the pivoted sashes, as well as the side rails of the sashes, are provided with inwardly projecting flanges, for connection by and through which the pivot pin passes. These flanges also permit the use of a very efficient form of weather

stop, *o*, which is made in two pieces, the lower piece extending from the pivot down and attached to the post, and the upper piece extending from the pivot up and attached to the sash or sashes.

The upright sheet metal posts in connection with the stationary glass are formed with the slip joints or pockets *p* for receiving the detachable glass caps *q*. These caps are held in place at their top ends by the overhanging member of curb *l*, and at their bottom ends by clips secured in pockets *p* and bent over the caps.

The pockets or channels *r* in the posts, in connection with the movable louvres, take care of any water that may find its way around past the ends of the louvres, conducting same down to the lower curb, from which it runs off. The member *n*, as shown in Fig. 194, should not extend over across the bottom of channels *r*, as this would dam the outlet from the channels and defeat the object for which they are provided.

The structural roof framing of the skylight consists of the curb angle *s* shown in Fig. 197, the T-shaped bars *t* and T-shaped hips and ridge. If the size is too great to allow of assembling in the shop the hips and ridge can be made of two angles, thus permitting shipment in four sections, which are easily riveted or bolted together on the building. The T-bars are secured to the angle curb, as well as the hips and ridge, by knees, and the junction of the hips, ridge and bars is effected by means of a gusset plate, to which all are riveted. It will be noted that no forging or fitting is called for on any of the structural work of either turret or roof, as it is cheaper to make connections by means of knees *i* and gusset plates, as shown at 4. This method of constructing the angle frame permits the use of the continuous sheet metal curb and ridge *u* without cutting. Ordinary sheet metal bar construction is slipped over the upturned web of the T-angle bars, hips and ridge, the condensation gutter members of the sheet metal bars resting on the flanges of the T-angles. All sheet metal connections should be riveted, laps being provided for this purpose. The condensation tubes 3 can also be made to answer as gutter dogs or braces.

If the skylight be a long one the knees 1 in Fig. 194 can be extended down, as indicated by dotted lines, to form a guide for holding the turret and roof curbs in proper relative position, and the upper end of the knee can be extended horizontally to form a connection for the cross tie 2. Curb *l* should be made in two pieces, with slip lock seams at the points 5 and 6, for which see Fig. 195.

Assuming the roof curb to be complete, the order or method of getting out and putting up the work is as follows, assuming the light to be too large to complete in the shop: After all the work is in knocked down form, put the turret together in

sections, leaving the corner seams open, of course, and leaving off the top of curb *l*. Then go to the building and set the angle curb *b* and erect the uprights *c*. Now slip the sheet metal turret sections over the structural work, and make the corner and other seams. Next bolt or rivet the curb angle *b'* in place and put the top on sheet metal curb *l*. Now all is ready for the erection of the structural roof frame, after which sheet metal curb *v* is set. Next in order is the setting of the sheet metal hips and ridge, and, lastly, the sheet metal bars, when the glazing can be done.

It will, of course, be understood that the section shapes of the sheet metal members throughout can be modified to suit any standard constructions in regard to connections between sashes and posts, louvres and stationary glass, etc., without interfering with the general construction shown. A skylight of structural iron construction thus incased in and protected by hollow sheet metal construction is far more fire resisting than when the structural work is not so protected. Better weather proof qualities are also obtained.

THE TURRET PART OF A SKYLIGHT

The accompanying diagrams are details of the turret part of a skylight designed to meet sharp competition by its simplicity. That it has strength, durability, and the like, is attested by the manufacture of hundreds of the type. Fig. 198 being a view of the sash part.

Fig. 199 is a vertical section of C D of Fig. 200. Part E is the gutter and the curb of the skylight and is made to answer for the usual top rail of a turret. Part F, Fig. 200, is soldered direct to this. If it is desired to keep the turret separate from the skylight, a rail of simple design can be used.

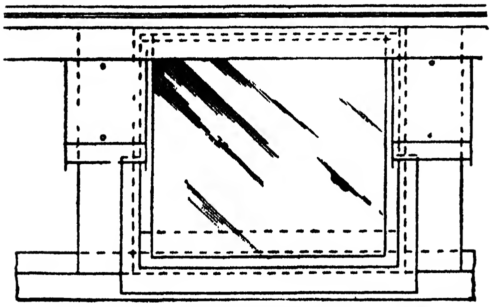


Fig. 198. Elevation of a Closed Sash.

Fig. 200 shows a horizontal section on A B of Fig. 199, which is the pivot line. The pivot is merely a wood screw. Part F is bent as shown and soldered where the edges meet at a corner.

Weather strips are made with a lip G, Fig. 199, and nailed with slate nails and also soldered at H, Fig. 199. From the corner of turret they extend down to the

bottom rail of the turret at I, Fig. 200, formed so as to pass around the corner of the turret and form the cap for the stationary light, as J, Fig. 200. Part K, Fig. 200, is shoulder soldered to the post for the glass rest of the stationary light.

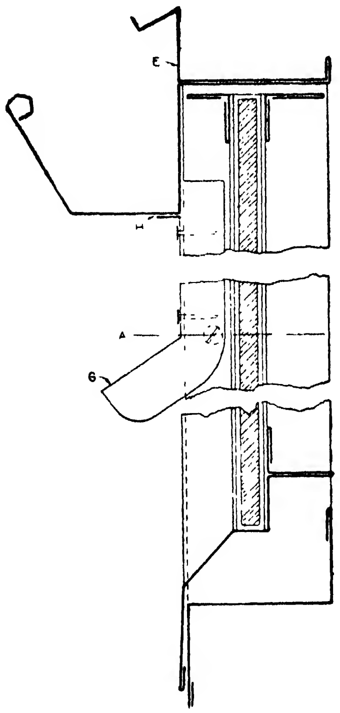


Fig. 199. Vertical Section on C D, Fig. 200

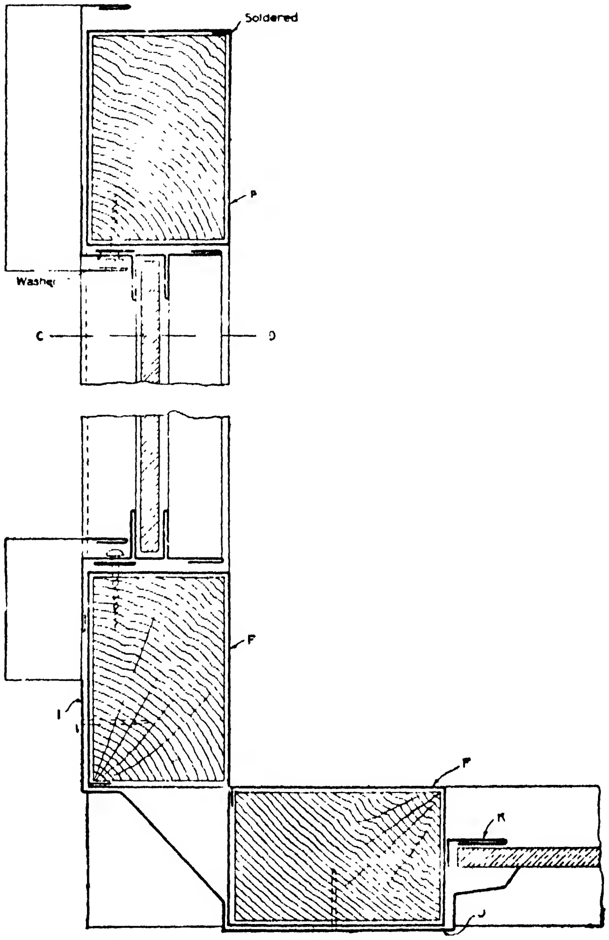


Fig. 200. Horizontal Section on A B, Fig. 199

A TURRET SKYLIGHT

In the presentation of methods of constructing and the designs of the many things to be made of sheet metal, the reader is to be cautioned that designs vary with the taste of their creators and what may appear suitable to one is wanting in many features to another. Cognizant of the above this exposition is presented with the remark that it is the embodiment of what is considered the good features of numerous individual designs.

The perspective Fig. 201 is a broken corner view of a turret with two stationary lights on one side and two sashes, one closed the other open, on the other side. It is understood, of course, that an ordinary hipped skylight is set on this turret, and that it is customary to attach a gutter to the skylight curb to prevent the drippings from the skylight from being blown into the sashes. The water in this gutter is conveyed to the roof by small leaders placed at the corners of the skylight; the leaders can be square or round and usually have a spout, or shoe, finish at the bottom.

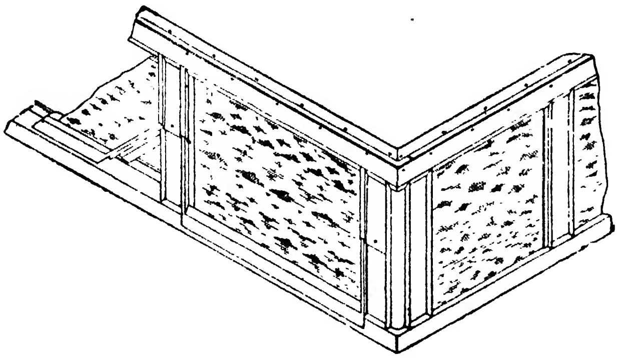
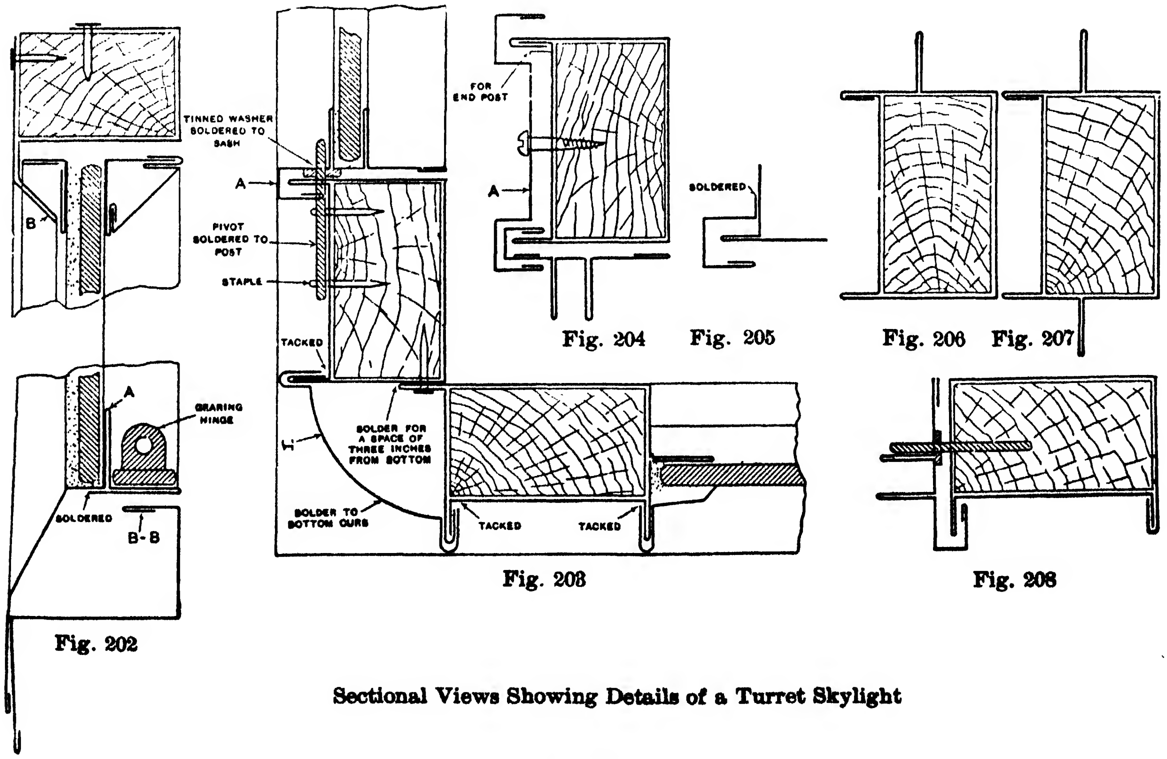


Fig. 201. Broken Corner View of Turret Skylight

A vertical section through the center of the sash is shown by Fig. 202. In this, attention is called to where the gearing hinge is bolted to the sash; this hinge



Sectional Views Showing Details of a Turret Skylight

should not be fastened to the part A, as the gearing exerts a tremendous pressure when closing a long line of sashes and would pull A away from the glass. To

allow of setting the upright posts in position, part B of the upper rail of the turret is notched and part B B of the lower rail, or curb, is cut away.

A horizontal section below the pivot line is shown by Fig. 203. As will be seen, a weather strip forms part of the sash from the pivot line down, engaging the outward flanges of the posts, insuring imperviousness to the weather. From the pivot line up the weather strip is separate from the sash, and both sides are made in one piece, held in place by soldering to part B of the vertical section, Fig. 202, and at the pivot by a wood screw as shown in Fig. 204. For the end post, or a post adjoining a stationary light, one side of the weather strip is omitted and an edge bent inward. In the choice of weather strips it may be said that many designers prefer making the strip as indicated by Fig. 205, that is, each side separate, contending that accurate spacing of the posts is requisite to obtain the best results; while the scheme in Fig. 205 lends itself to easy adjustment, if space from post to post is not exactly as required by Fig. 204 relative to the distance sash side is to have from the post. It is, however, not neat in appearance and leaves the pivot exposed. Figs. 206 and 207 are other posts needed for the turret—Fig. 206 in case a stationary light is next to a sash and Fig. 207 for post between two stationary lights.

The attractive feature of this design is the weather strip. By this arrangement of the pivot, and the notching of the posts, as per Fig. 209, the upper strip overlaps the lower one of the sash about ¼ of an inch, which is ample to prevent the entrance of snow or rain. This as Fig. 201 shows, presents a very neat appearance, there being no need of the unsightly lip of Fig. 210, which is not weather tight.

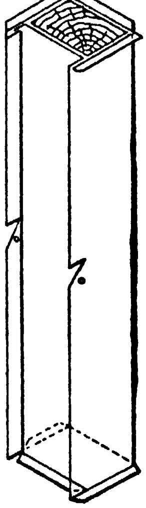


Fig. 209

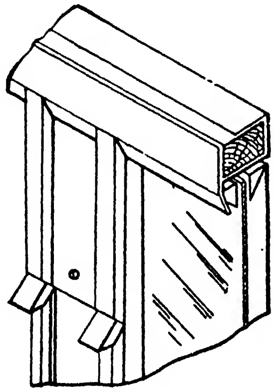


Fig. 210

Details of Posts Next Swinging Sash

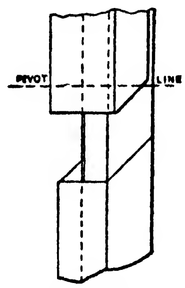


Fig. 211

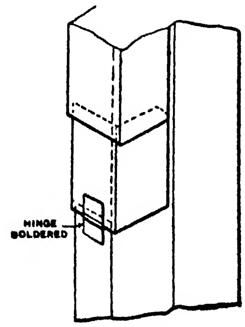


Fig. 212

Suggestions for Posts Next Swinging Sash

Should it be desired, however, to place the pivot as per Fig. 208, then as the weather strip of the sash must be cut quite some distance below the pivot line, like Fig. 211, leaving an opening between the upper and lower weather strips, a lip as indicated in Fig. 210 is soldered to the upper strip. As stated, this is ugly and not stormproof, so the ingenious contrivance employed by a clever designer is submitted as an alternative; and is shown by Fig. 212. When the sash opens and closes this travels up and down within the upper strip.

The assembling procedure of the turret is to make the sides complete in the shop, the sashes placed in position and also the weather strips and the like; sashes are moved to see that they work easily and then kept closed, either by wiring or

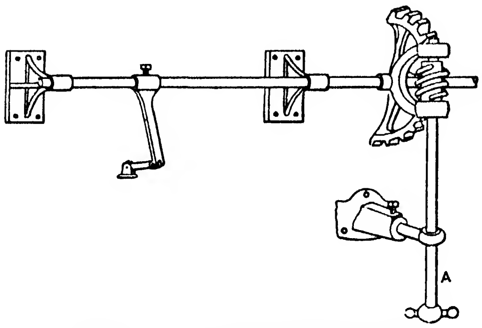


Fig. 213. An Operating Gearing

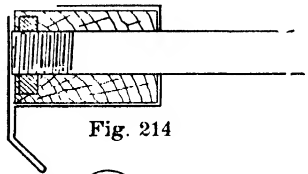


Fig. 214

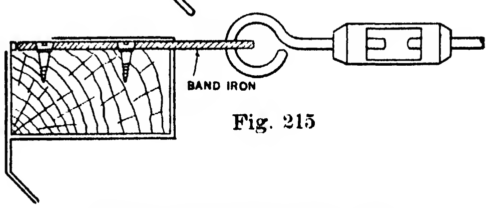


Fig. 215

Methods of Tying Upper Rail

by tacking the apron of the sash to the lower rail. On the job, if the skylight is a small one and for convenience, the four sides are brought together and soldered and nailed and circular corner cap placed in. It is then set on the roof curb. If the skylight is large the four sides are built directly on the roof curb. The hipped skylight is now mounted and securely anchored to the turret and the entire job glazed and capped and the gearing, for the operation of the sashes, attached either to the turret posts or the roof curb, the posts being preferable.

There are many excellent types of gearing on the market; a popular style is illustrated by Fig. 213. By the use of bevel gears at the corners all four sides can be operated simultaneously by the one lifting power and drop A. It is not good practice though, to operate too many sashes with one lifting power, for it will be found that those sashes farthest from the power will not work in unison with the others, due perhaps, to lost motion, slipping of the

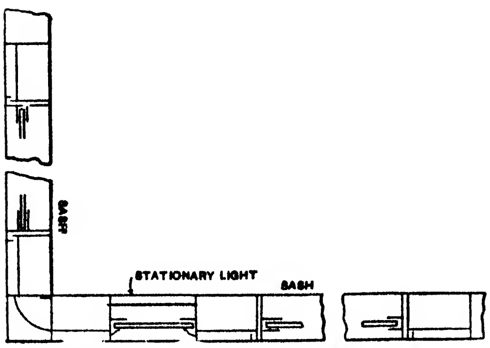


Fig. 216. Arrangement of Lights

setting screw and the elastic resistance to torsion in the rods. Seemingly there is no rule to fix the amount of load; experimenting only can determine it.

A hipped skylight has the same stresses as a pitched roof, but as it has no bottom chord, like a roof truss, to resist the thrust of the bars, glass, etc., on its curb, this stress must be taken care of. In small turrets the lateral stiffness of the skylight curb and the top rail of the turret is sufficient to overcome this outward pressure. In a large light it is not so much the length as the width of the skylight that governs in the need of balancing the thrust; as for instance a 6 ft. × 8 ft. needs no tying, whereas a 6 ft. × 15 ft. would; hence the upper rail of the turret should be tied. Some use common gas pipe as shown in Fig. 214, but the rod and turnbuckle, as per Fig. 215, looks well, and is more scientific, as it were.

Usually the skylight mounted on the turret is what is known in trade parlance as a hipped ridge light, *i. e.*, a skylight without a ventilator—just a ridge bar. This is not approvable, and a vent should be placed in the skylight; not necessarily a large one, but of ample size to allow the escape of foul air when the sashes are closed. Even when sashes are open it will help, materially, to circulate the air above the sashes.

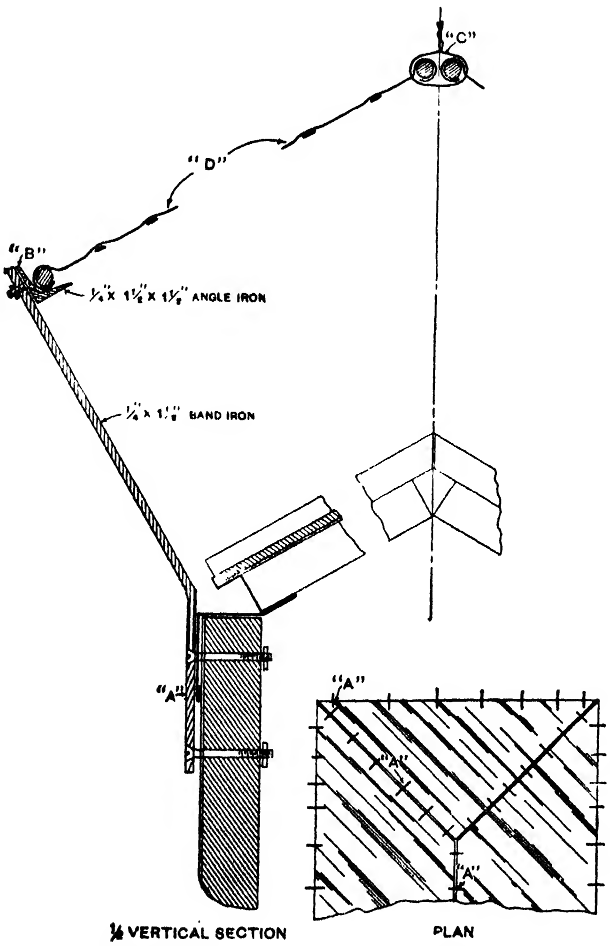


Fig. 217. A Method of Protecting Glass

When laying out a turret for the sash opening and the like, and sashes are wanted on all four sides, a stationary light is provided at all four corners, as shown in Fig. 216. This allows the two sashes at the corner and in the adjacent sides to open without striking each other. Although this is quite obvious, it is well to remember it. Generally the width of this stationary light is half the hight of the sash.

SCREEN PROTECTION FOR SKYLIGHTS

In the matter of screen protection for skylights, it is the consensus of

opinion that it is useless to place the screen directly on the caps of the skylights. Screens naturally give somewhat when subjected to shock, and if laid on the caps the consequent concussion will be transmitted to the skylight itself and result in a breakage of the glass. To be of any value screens must be, say a distance of 1 ft. above and independent of the skylight. The accompanying sketch Fig. 217, shows a method of construction that will give adequate protection for skylights up to say 10 ft. in width. For larger skylights conditions will govern the construction of the supports for the screens, and if one is conversant with structural steel design a method of making the supports of light steel shapes will suggest itself. Screens are generally bought from concerns making a specialty of their manufacture. An excellent style is that with diagonal mesh commonly used for show window protection. In the diagram, D shows the screen proper, which is wired at the ridge, as indicated by C, also the hips, and at the angle iron supports B. The spacing of the band supports depends on the size of the screen; and an idea as to how the screens are made is shown by the plan, A being the wires called C in the vertical section.

A REINFORCED LOUVRE TOP OF A VENTILATING CHIMNEY

A certain class of buildings such as hospitals, etc., require to be especially well ventilated, and the system often includes a brick stack or chimney for inspiration or aspiration, according to whether the air is taken in near the ground and discharged through the chimney, or taken in from the top of the chimney and discharged near the ground. In any event a covering for the stack is necessary, and this covering must keep out the weather and allow for free passage of air to the extent of the capacity of the stack and protect the brick work of the top of the stack from rain and sun

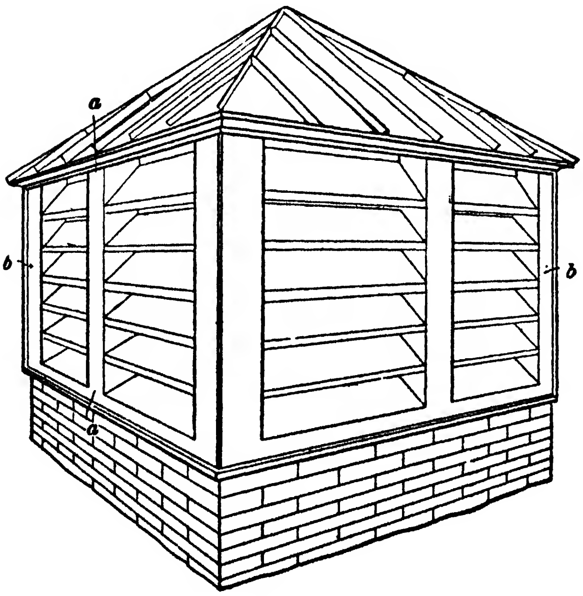


Fig. 218. Perspective View of Ventilator

Fig. 218 shows the top of a stack provided with a typical form of louvred cover. There are several methods of constructing these covers and they vary in accordance with the size of the stack. A large stack requires a structural iron frame

work for supporting the sheet metal work against wind pressure, snow, ice, etc., no dependence being placed on the sheet metal for strength. A small chimney can be adequately covered by a top constructed of sheet metal work alone, without being

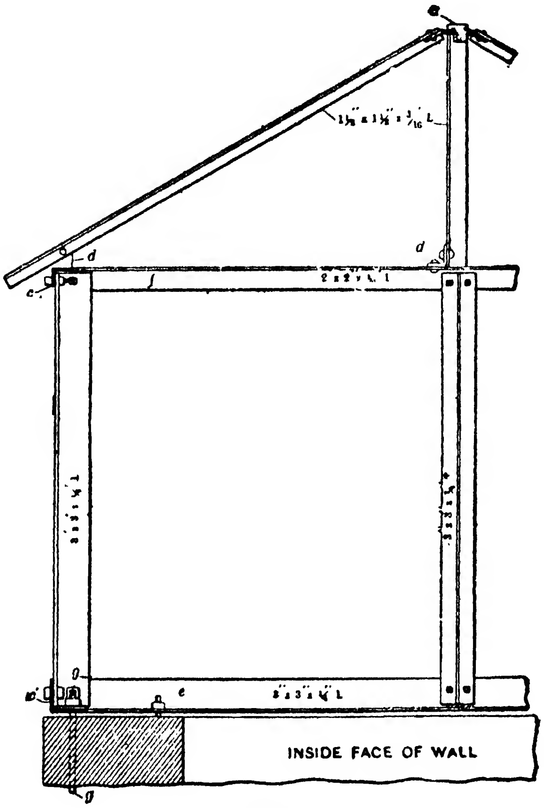


Fig. 219

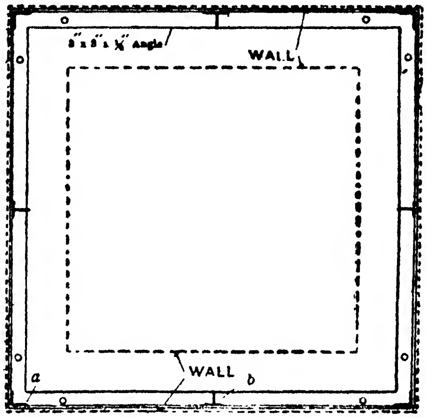


Fig. 220

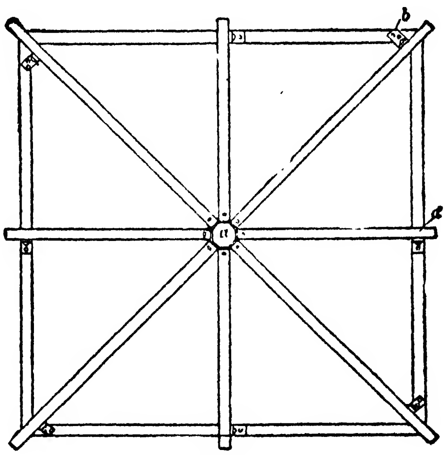


Fig. 221.

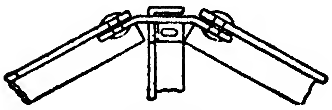


Fig. 222

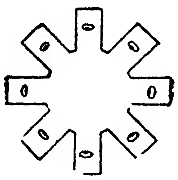


Fig. 223

General Details of Louvre Ventilator

strengthened by structural iron work. Fig. 218 represents a stack, say 6 feet square, which may be considered large enough to require structural iron framing.

Fig. 219 is a vertical section on *a a*, of Fig. 218, and Fig. 220 a horizontal section on *b b*, of Fig. 218; Fig. 221 a plan looking down on top, and all show the structural iron framing. Fig. 222 is a detail showing how the hip and roof angles are connected at *a*, Figs. 219 and 221. Fig. 223 shows the octagonally notched connecting piece, made of iron ¼ inch thick, and which it will be seen forms the

integral connection between all of the angles. Fig. 224 is a detail showing how the hip angles are connected to the horizontal purlin angles *f* at *b*, Fig. 221. Fig. 225 shows the connection at *d*, and Fig. 226 the connection at *c* and c^1, in Fig. 219.

The horizontal angle *e*, which rests on top of the brick work, should on a stack of this size be not less than $3 \times 3 \times \frac{1}{4}$ inches in size. The upright angles and tees should be not less than $3 \times 3 \times \frac{1}{4}$ inches; the purlin angle *f* not less than $2 \times 2 \times$ 3-16 inches, and the rafter and hip angles not less than $1\frac{1}{2} \times 1\frac{1}{2} \times$ 3-16 inches. It will be noted that all angles are cut and connected in such a manner that no forging is

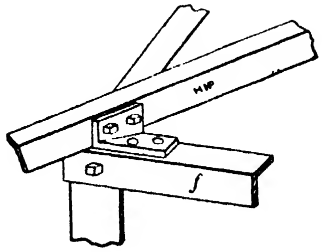


Fig. 224

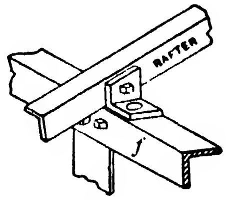


Fig. 225

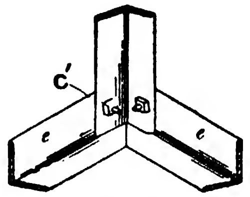


Fig. 226

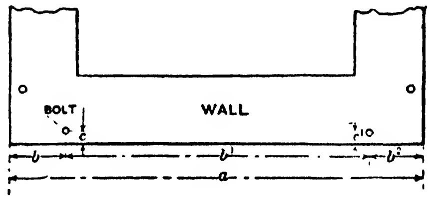
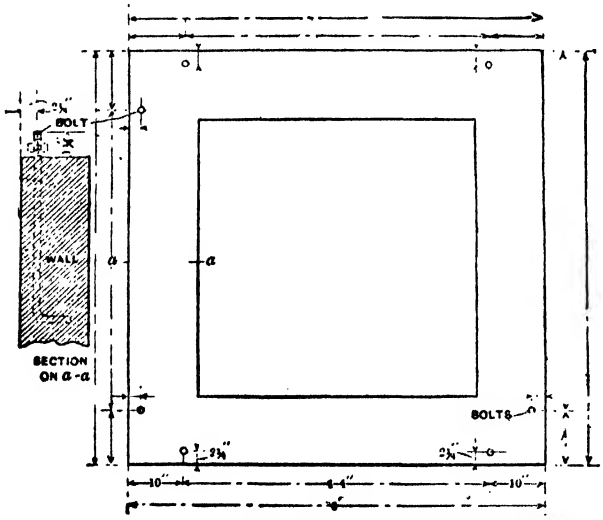


Fig. 228



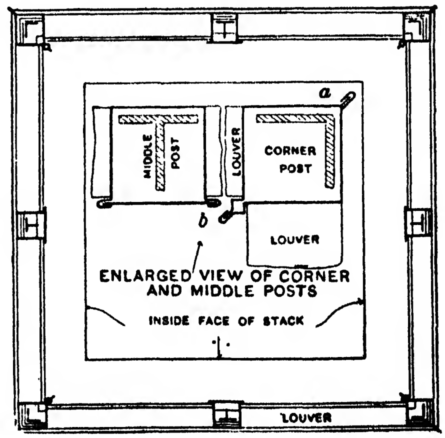
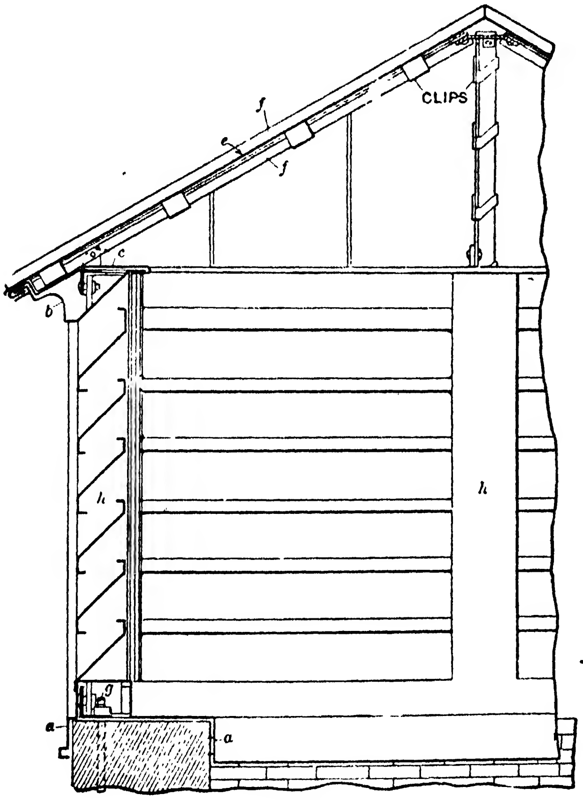
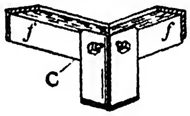


Fig. 227 Other Details of Louvre Ventilator Fig. 229.

necessary It is always cheaper to connect the members of structural work by means of clips and knees than to cut off one of the webs or flanges, and forge and punch the other web or flange.

It will be seen that the wall angle *e*, Fig. 219, is secured to the brick work by means of long bolts, *g*, built into the masonry. These bolts should be ½ inch in diameter and not less than 3 feet long. It is of course necessary to see that these bolts are provided and properly built in by the masons. There should be eight in a stack of this size, and a sketch showing their location and the hight they must project above the finished masonry, as in Fig. 227, should be furnished the masons, so that they will get them somewhere near the right place. It is seldom that a mason will get them near enough to the dimensions shown to justify punching the holes for the bolts in the angle *e* without taking special measurements





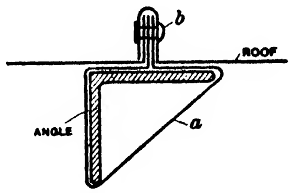


Fig. 231

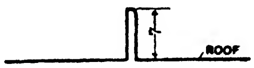


Fig. 232

Fig. 233

Fig. 230

Vertical Section of the Sheet Metal Work and Other Details

after the masonry is complete and the bolts permanently fixed. In measuring the top of the stack before starting the metal work (and this should not be started until after these measures have been obtained, as the masons cannot be depended upon to conform to the architect's drawings to within an inch), not only the outside dimensions of the stack, as indicated at *a*, Fig. 228, should be taken, but the bolts should be located as related to the measurements, as indicated at *b*, b^1, and b^2, and also as related to the face of the stack, as indicated at *c* and c^1, Fig. 228.

Fig. 229 is a horizontal section on *b b*, Fig. 218, and Fig. 230 a vertical section on *a a*, showing the sheet metal work, as related to the structural work. It will be seen that the horizontal sheet metal member *a*, Fig. 230, entirely covers the brick work, acting as a wall cap. The top horizontal member *b*, covering the angle purlin *f*, should be made with a separate cap, *c*, to be placed on afterward, as described later.

The roof *e* locks over the edge of *b* and *c*, as shown, and is stiffened by standing seams. Fig. 231 is a section of *f f* of Fig. 230, showing how the roof is provided with a standing seam over the centers of hip and roof angles and are secured thereto by clips *a*. The roof should also be provided with stiffening ribs, as in Fig. 232, about 12 inches apart and about 1 inch high.

By the use of lock seams *a* and *b*, Fig. 229, the louvre work can be put together in the shop in four sections, leaving the caps *c*, Fig. 230, loose. The roof should be made in eight sections, leaving the seams over the rafter and hip angles to be made on the outside. The structural iron work should be prepared complete, ready for assembling. The erection is accomplished in the following order:

First place angles *e* in place, secure by the bolts built in the masonry and set up the corner angles *a*, and intermediate tees *b*, Fig. 220, bolting them to angles *e*. Next set the sheet metal louvre sections down over these angles. Then place purlin angle *f*, bolting it to the uprights *a* and *b*. Purlin angles *f* should have the knees to which the rafter and hip angles are bolted riveted on at the shop. After *f* has been bolted in place, place cap *c* in position. The lock edges of cap *c* should be left standing square, as indicated at Fig. 233, and after it is placed in position the edges folded around as indicated. It is, of course, necessary to punch holes in *c* for the knees to project through.

Next, the rafter and hip angles are bolted in place, and lastly the roof is put on. Clips *a*, Fig. 231, should be at least 2 inches wide, and not over 12 inches apart, and after the roof is placed on over them, and seamed, rivets *b* should pass through the clip, securing all together. The eaves of the roof and the edges of *b* and *c*, Fig. 230, are riveted about 12 inches apart, the rivets passing through *b* and *c*, securing all three together.

In order to prevent the building of birds' nests in the ventilator top, a wire netting of sufficiently small mesh should be secured to the inside of the louvres to prevent the entrance of birds. It is, of course, necessary to put in the netting either at the shop or before the roof is put on. In the shop is preferable, for then the louvre side can be laid flat and the netting tacked on.

If such a top is to be placed on an old stack, or in cases where the masons have not built in bolts for securing the top, angle *e* can be secured by straps hooked over its top edge and extending down on the face of the chimney three or four feet, and bolted with at least two $\frac{1}{2} \times 4$-inch expansion bolts, placed near the lower end, as in Fig. 234. It is useless to bolt such a strap near the top of the brick work, as such bolts only get the benefit of the weight of the masonry above them and are likely to disrupt the masonry, so as to be of no benefit whatever. These straps should be $1\frac{1}{2} \times \frac{1}{4}$ inches in size.

If appearances should forbid the use of such straps on the outside, heavier material can be used and the strap placed on the inside of the stack, as indicated by the dotted lines *a*, Fig. 234. If in the latter case the thickness of the wall is such as to make the distance *b* too great, holes can be punched in the roof and hip angles and stout wires connected from it to strap *a* at the point *c*, which will hold the top down, while strap *a* and the flange of the sheet metal work which projects down around the brick work will hold it laterally.

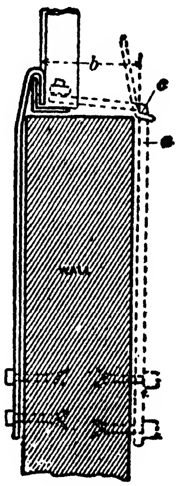


Fig. 234. Anchors

Similar tops for stacks of smaller size can have the sheet metal work constructed in substantially the same manner as shown, except that the horizontal members *a* and *b* and the upright posts *h*, Fig. 230, should be made of a heavier gauge of metal, and all connections be securely riveted, ample laps being allowed for the purpose.

In similar tops of large size, or even in the size shown, when located in sections where the wind often attains hurricane velocity the roof should be sheathed over with 1-inch boards securely fastened to the roof and hip angles. The latter should be punched at frequent intervals to accommodate screws for this purpose. Without the sheathing, the roofs are almost certain to blow off. The size of the angles and tees comprising the structural work should also be proportionately increased in larger tops.

A LOUVRE VENTILATOR

On page 880 is shown the method of constructing a louvre ventilator reinforced by wrought steel structural shapes. Herewith is exemplified the method of making this ventilator by a scheme that eliminates preliminary wrought iron work and allows the use of shop, or standard design of louvre frame and skylight.

A design is shown by Fig. 239, which being susceptible to modification should suggest a way for the reader to use his own standard skylight patterns and profiles, for it is practically an ordinary skylight job, except that instead of glass, sheet metal is used to make the roof; a popular practice and employed on many large jobs. Fig. 235 is a perspective view of the complete ventilator. A condensed vertical section on line A B of Fig. 236 is shown by Fig. 239, and is a plan of a job, the outside wall or curb measurement of which is 6×6. By this method the limitation of size is about that of a turret skylight. In fact, by enlarging sections and properly bracing and tieing part A, Fig. 239, there is no limit. For an extra large ventilator and owing to the thrust of the roof which tends to spread the ventilator, a good scheme for tieing this part A is by a rod and turnbuckle, secured to the top rail by a piece of band iron held by wood screws. And as the ventilators are usually ten or twelve louvres high it is well to have a gutter, as shown by Fig. 237, to catch the water from the roof part.

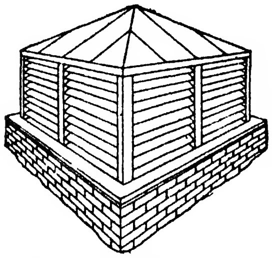


Fig 235. Perspective

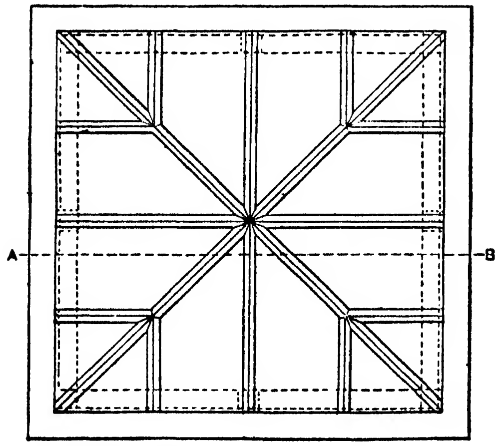


Fig. 236 Plan of Louvre Ventilator

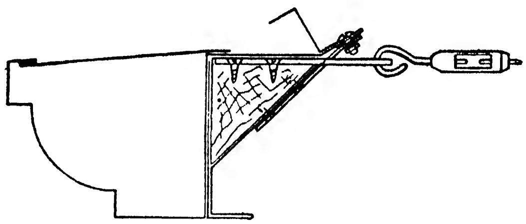


Fig. 237. Scheme to Prevent Skylight Spreading

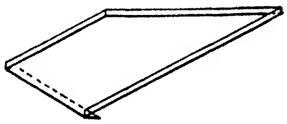


Fig. 238. Plan of Forming Roof Sheets

The manner of assembling these ventilators is to have corner post of similar section to the section shown in Fig. 239, excepting that the shoulders would be on one corner only at the back, instead of opposite corners, and it would be in two parts. The curb would be soldered together on the four corners, then each side of the louvre frame assembled with the top rail (under part A) and all the louvres and the center post, after which all four sides are brought together and the locks of the corner post clinched, also the posts soldered to the curb. It would make it easier to cart to the building and hoist to the roof, if the four sides were shipped before joining the corners.

The upper or roof part is laid out, formed up and assembled just as if it was an ordinary 6 ft. × 6 ft. skylight and was glazed with the customary ribbed or wire mesh glass. Naturally, if light was desired in the ventilating stack, glass could be used. As a suggestion, it is stated that it would facilitate shipping if this top part was left off and mounted on the louvre part, after setting this part on the stack.

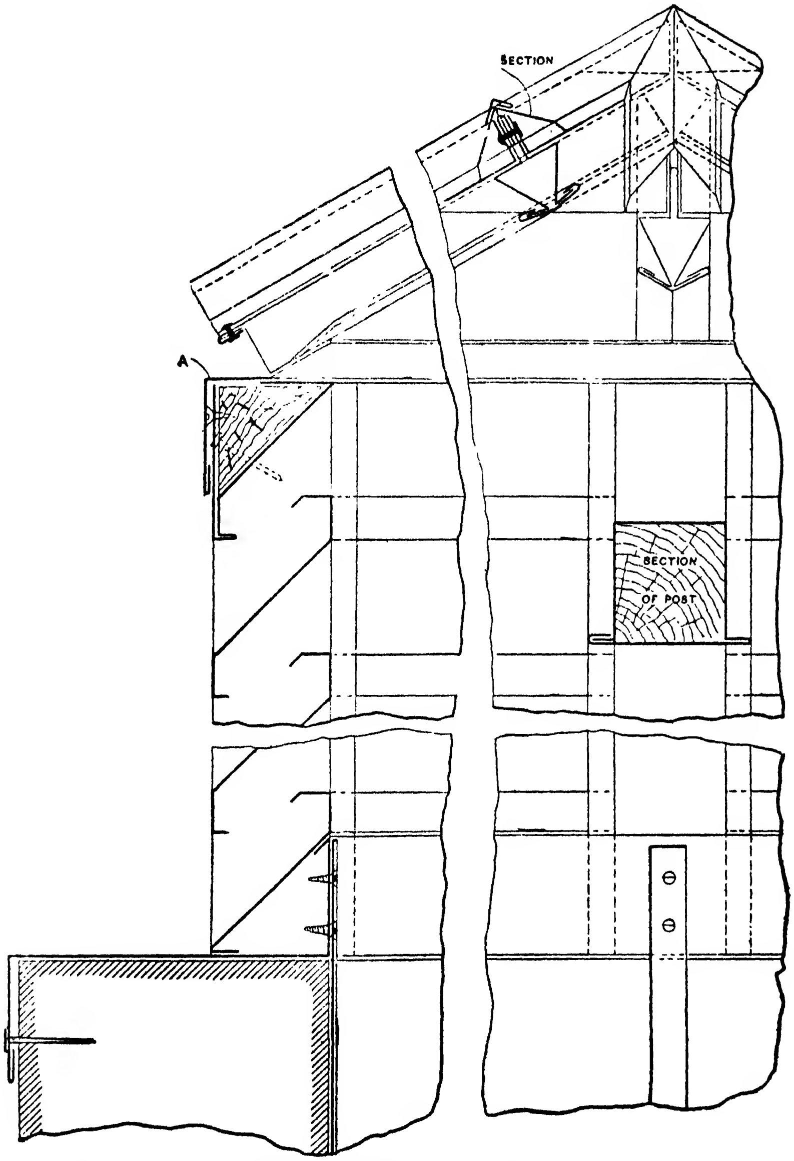


Fig. 239. Louvre Ventilator Without Preliminary Steel Shapes

The roof sheets are cut to the same shape as the glass would be. Edges are allowed to the sheets and are formed as shown by Fig. 238. After which they are set in between the bars (resting on the glass rests of the bars) and riveted to the comb part of the bars and the lower edge clinched and riveted to the skylight curb, all as shown in Fig. 239. Ordinary skylight caps, secured to the bars in the same manner as if glass was used instead of sheet metal, make watertight joint, the joint of the sheet metal roof piece with the bars. These roof sheets should be heavily crimped crosswise, inasmuch as they have no support between the bars and would sag. In view of this, it is well to make the spacing of the bars as small as consistent with the cost of the article and its appearance. For it is self-evident that, the closer bars are, the more would be necessary.

DETAILS OF A LIFTING SASH

In this article details are shown for a lifting sash and referring to Fig. 240, A B C D is a reproduction of the sketch made to give a general idea of the formation of the wrought iron construction, with opening in which the sash are to be operated. Fig. 241 is a general view of the finished sash, and measures, it is assumed,

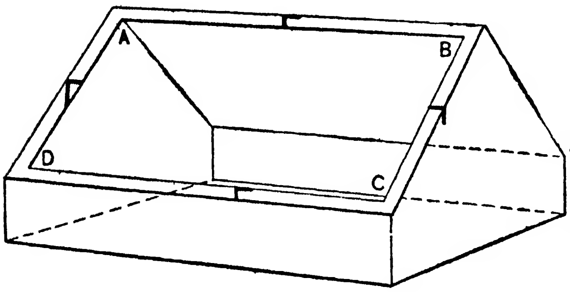


Fig. 240. Sketch of Wrought Iron Construction

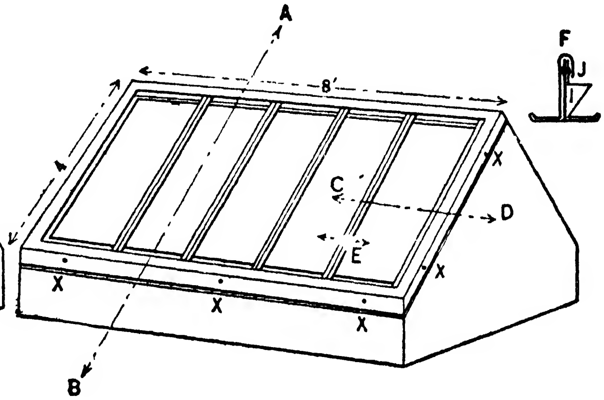


Fig. 241. General View of Finished Sash

4×8 feet, and is fastened to the frame work by means of the bolts X X, etc., in the manner indicated at X, in Fig. 243. When making a constructive drawing for a skylight sash, as shown in Fig. 241, always take into consideration the size of the opening and the span of the bar. A bar of 4 feet in length, as shown would require no further strengthening than the bent sheet metal, while a bar, say, 8 feet long would have to be reinforced by core plates 3-16 inch by 1½ or 2 inches, as in diagram F, which shows a half sash bar, reinforced by the core I and riveted at J. Assume however, the length of the bar as 4 feet and make constructive drawings accordingly.

In Fig. 242 is a detailed section through A B of Fig. 241, in which A and B of Fig. 242 show angle irons, and C the copper flashings extending up from the roof and flanging around the inner side of the angle at D, while E shows the back covering of the bulkhead, with a double standing seam at F, covering the top of the angle iron and turning down so as to come about ¼ inch below the skylight rafters or bars with a double edge at G. The double seam at F is there placed, so that the top cap Y or guard can be fastened to it. In line with the angle iron construct the half sash bar H, bending it in the manner shown with the seam at the top. This half bar should extend up on the top angle as far as I, and on the lower angle as far as J, and fit well against the copper flashing at K at the bottom and L at the top.

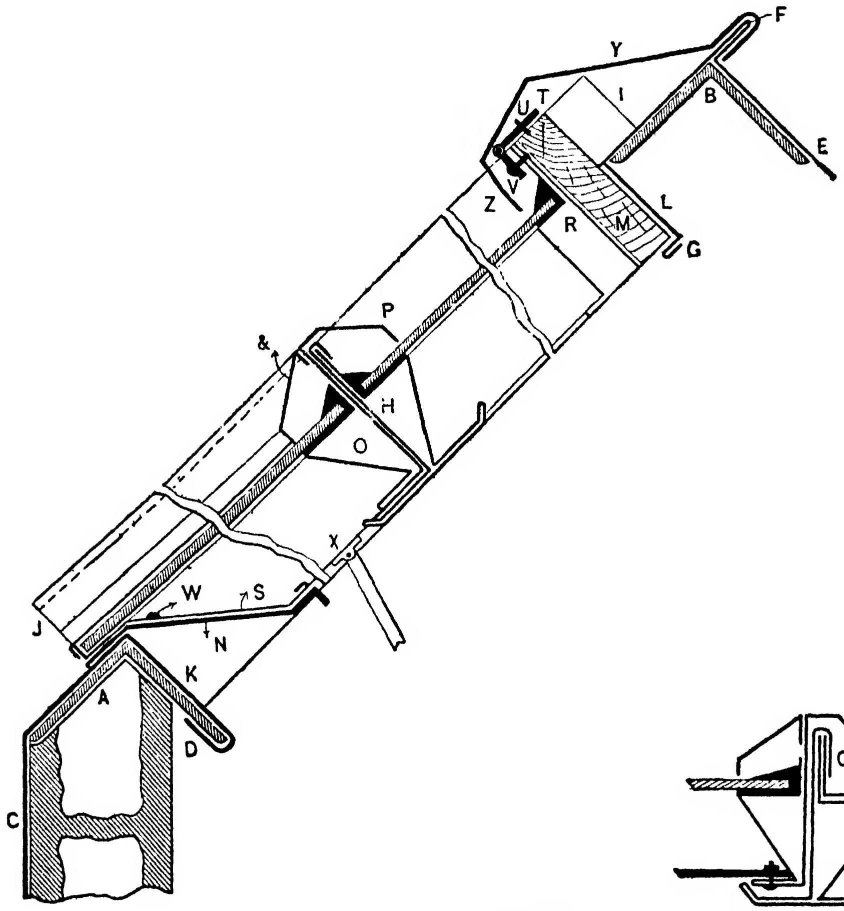


Fig. 242. Detailed Section on Line A B of Fig. 241

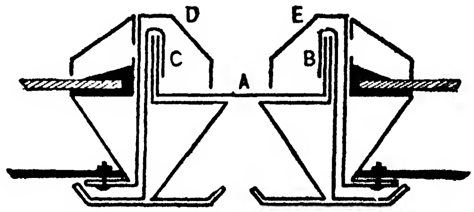


Fig. 244. Section at E of Fig. 241

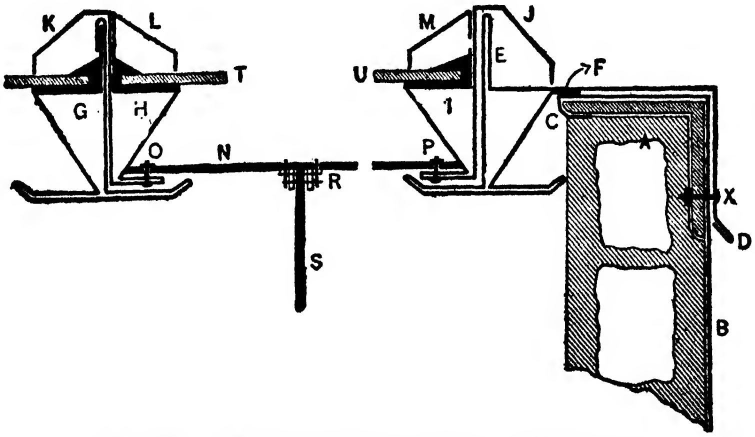


Fig. 243. Detailed Section on Line C D of Fig. 241

The spacing of the bars being determined, obtain wood furring about 1½ inches wide and of the depth of the sash bar, and incase it with metal, as shown at M, at the top. This is soldered firmly on each side of the half bar. At the bottom construct a curb or wash, as shown at N, bent in the manner indicated, giving the wash N sufficient pitch to throw the water to the outside. This is also firmly soldered to each side of the half bar. Then the two half bars H, the top curb M and bottom curb N will be the frame into which the sash must fit and operate without leakage.

On the inside of the half bar H construct the inner bar O, on to which form the cap P, having the seam above the putty line, as shown, which should be well soldered. At the top, to conform to the width of the frame, construct the bar R, and the bottom, to fit into the curb N, construct the shape S, turning up at the front, to keep the glass from sliding down, as shown. This constitutes the inner sash and is hinged at the top to the frame by the hinge T, screwing it into the wooden frame M at U and riveting the top bar R at V. At W at the bottom ½-inch condensation holes are placed in every sash, which allows the condensation, if any, to run to the outside. When operating the sash the usual skylight gearings are employed and the hinge X is used in connection with a band iron strap.

When the glass is in position and puttied, a top hood or cap must be placed over the hinged joint, as at Y, lapping to the glass at Z and double seaming to the standing seam F, as shown. A half cap & formed as shown, is placed over the puttied joint of the inner sash, tacking same with solder about every 12 inches. The cap Y runs along the entire length of the skylight, and is carefully notched out where required for the bars.

In Fig. 243 is a detailed section through C D of Fig. 241, which also shows how the end bar is formed. As in Fig. 242, the line of the glass rest must run in line with the angle, as shown in Fig. 243, in which A is the angle iron and B the copper covering on the side of the bulkhead, flashing over and around the angle iron at C. Over this flashing the cap D is placed, which is formed direct to the end bar E, the joint being at F, which can be soldered or riveted. G shows the half bar, which is the same as H in Fig. 242, while H and I of Fig. 243 show the raising sash bar, similar to O of Fig. 242. It will be noticed that the bars H and I in Fig. 243 have the caps J and K attached, while the inside caps L and M are separate, as before explained. N represents the cross brace, bolted at O and P, on to which the hinge R is riveted and pivoted to the strap S.

In making operating sashes of this kind it is sometimes necessary to gain as much air as possible; then instead of raising each alternate sash, the half bars G

are placed as close as possible together, as shown in Fig. 244. Then the valley A is placed between the locks C and B, which allows for the expansion and contraction of the copper, the caps of the sash bars D and E overlapping, as shown.

REPLACING AND CLEANING SKYLIGHT GLASS

When repairing skylights and replacing broken glass the workmen should be instructed to remove the broken lights with the maximum care possible with a job that at best is not relished by workmen. Although the glass may be so dirty as to be really opaque it can be cleaned and stored for use for some other skylight requiring a light which may be cut from this broken one. A careful foreman will see to it that, when a collection of broken lights becomes too much for the storage allowed, the skylights to be made are so designed as to use up this collection.

To clean the glass it should be laid on a smooth bench and all the hard putty adhering scraped off. A red-hot piece of iron held on the putty has been found of considerable assistance to the scraping. Then with a solution of muriatic (sulphuric would do) acid and water, in which the acid predominates, in a suitable earthenware receptacle and a box of sharp sand, the glass is washed off on both sides by wetting a rag in the liquid and briskly scouring the glass, sprinkling a handful of sand on the glass now and then, watching carefully, though, to see to it that the sand does not scratch the glass. If spots of dirt are obstinate it is well to leave some very wet sand on each spot, and if this is not efficacious in a few moments pour some pure acid on the part. When all the dirt has been removed, the glass should be rinsed with clear water, to which a little ammonia may be added to advantage. It has been said that if the glass is polished with a soft woolen rag dirt will not readily adhere again. This work can be done by unskilled labor and should prove profitable, in comparison with the initial cost of the glass.

A caution may not be out of place relative to the above remark in stating that glass should never, if it can be avoided, be cleaned while in the skylight, because of the danger of greater breakage, the inaccessibility of the under surface of the glass, which usually is the dirtiest, and the danger of the acid corroding the metal work of the skylight. The removal of the glass and reglazing are beneficial for the skylight, inasmuch as the new putty will give additional assurance against leaks. While doing this work the building should be protected over night by placing a tarpaulin over the skylight.

EXPANSION PROVISIONS IN SKYLIGHTS AND GUTTERS

Inasmuch as considerable provision is made these days for the expansion and contraction of building, the following explanation of how allowance was made for this movement in the skylights and the like, should be of interest.

The building is a package or freight station of some 400×80 ft., with a double pitch skylight at the center of roof and running its entire length. Midway from the eaves and this skylight, on both sides, is a row of small double pitch skylights set on concrete curbs. It has corrugated siding, eave molding and hanging gutter. There are two expansion joints cutting the long side of the building, making it

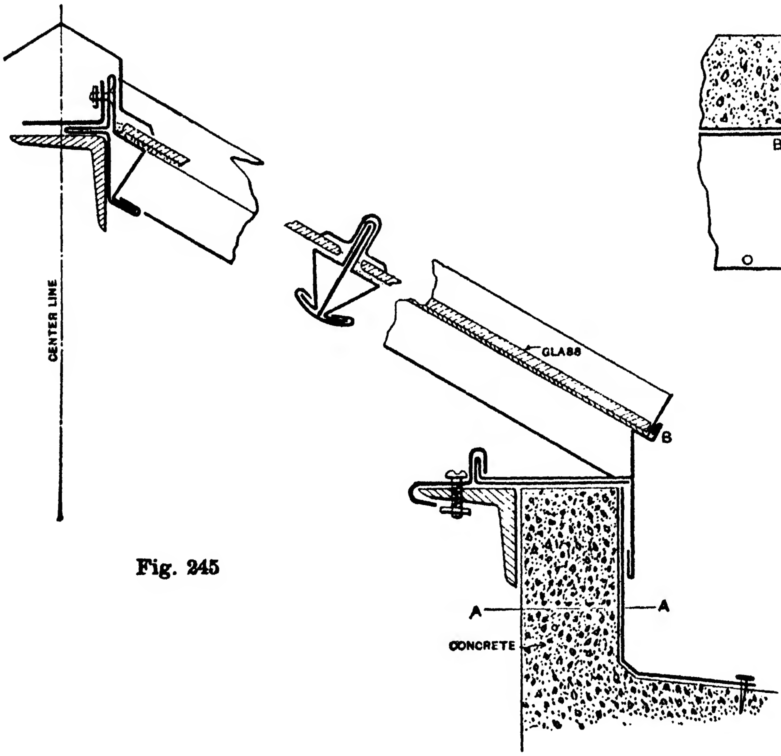


Fig. 245

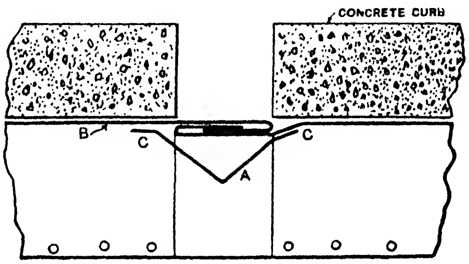


Fig. 246

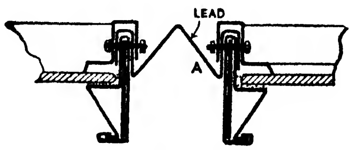


Fig. 247

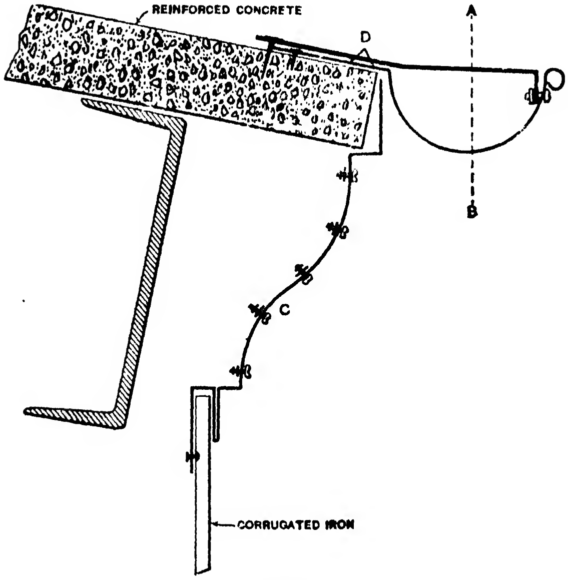
Construction of the Skylight and Arrangements for Expansion

really three separate buildings. As sheet metal only enters in this explanation, it will not be shown how the joints were made in the structural steel work.

Fig. 245 is a half section of the skylight. The bars are, if memory serves correctly, 103 in. long. While sketches are rather crude, still one can get an idea of the construction of the skylight. Fig. 246 is a horizontal section through the cement curb at about A A in Fig. 245. It shows how the joint was made in flashing B, Fig. 246. Fig. 247 is a section at the expansion joint, through the skylight looking along line B, Fig. 245. It is simply two half bars and the gap

bridged over and made weather tight by lead cap A. This lead cap is mitered at the ridge, also at curb, and carried down to the roof A, Fig. 246, and soldered to flashing B at C C, Fig. 246.

Fig. 248 is typical section at the eaves of the roof. There are no expansion joints in the siding, it being presumed that corrugations will take care of the expansion and contraction. The gutters, as shown by Fig. 249, are kept 3 in. apart,



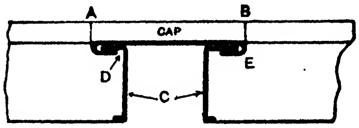
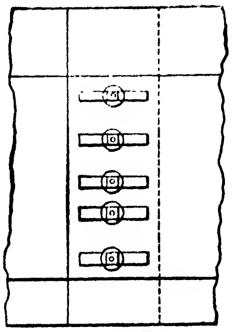


Fig. 249

Fig. 250

Fig. 251



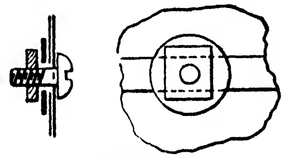


Fig. 248 Fig. 252 Fig. 253

The Gutter and Eaves Moldings and Expansion Provisions

with heads, C, having an edge, D, the heads being soldered to the gutters. Then a cap with edges bent, as shown by E, Fig. 249, but sharp on roof flanges, is soldered to the gutter roof flange at A, but left loose at B. Of course, the cap could not be nailed to the roof at B, and trouble was experienced in keeping it from sticking up like in Fig. 250. This was remedied by clinching a small piece of iron, F, around it and the gutter flange, as in Fig. 251. Fig. 249 is a section on A B, Fig. 248.

At the expansion joints the eave molding C, Fig. 248, is just bolted together with 3-16-in. seam bolts. The molding is lapped 4 in. The section lapping on the inside has slots cut 3 in. long, these allowing the desired movement, as illustrated by Fig. 252. Fig. 253 is full size and shows more clearly the slot, washer and nut.

It will be noted that the gravel guard or stop D in Fig. 248 is not integral to the gutter, but made separate and soldered to the roof flange after the gutter is set. At the joint this guard is lapped, but not soldered, and is a characteristic method of this shop. All sheet metal on this job was genuine iron, as specified by the engineer in charge.

CONDENSATION GUTTERS ON THE INSIDE OF WINDOWS

In furnishing the roofing and cornice work for churches the specifications usually call for condensation gutters on all chapel and dormer windows. For the benefit of sheet metal workers who may be called upon to do this class of work the following should prove interesting:

It is a well-known fact that warm air will rise upward, and when coming in contact with a cold surface, such as glass, for instance, the glass begins to sweat on

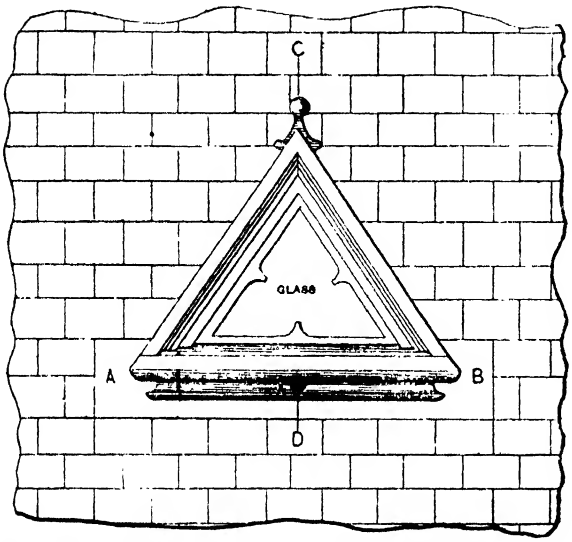


Fig. 254. Front Elevation of a Dormer Window on a Pitched Roof

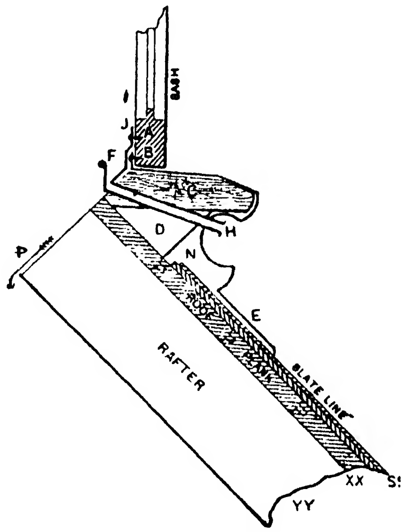


Fig. 256. Enlarged View, Showing Fastening of Gutter in Fig. 255

the side having the warm air, thereby causing not a little moisture to accumulate; an example of which can be seen in our dwellings during the winter months.

Such was the case with a church in mind, the church being heated day and night, and all windows and ventilators tightly closed in cold weather. The chapel and dormer windows began to sweat continually, thereby causing the moisture to run down the wooden sill on the inside and ruin the frescoed walls. To overcome this a sheet metal gutter was placed on the inside of each window, connected to a metal tube, which conveyed the condensed moisture to the outside. The descriptions and the diagrams herewith will show how the work was done. In Fig. 254 is shown the front elevation of a metal dormer window on a pitched roof, the roof covering being slate. A and B represent the flashing around the sill of the dormer, which is soldered and riveted water tight to the dormer in the shop, and is slated in with the courses. X represents the outlet of the tube, which is connected to the gutter on the inside. The glass in the wooden sash is shown in Fig. 254. Fig. 255 represents a sectional view on line C D in Fig. 254, and shows

the rafter, Y Y, on which the roof boards, X X, are nailed, the slates being shown by H H. The dormer was made of sheet metal, as stated, and the wooden sash, shown by K K in Fig. 255, was placed in last, or after the dormer was set. The moisture dripping from the glass in the sash K K would follow the arrow J and drip inside of the building. A gutter was placed as shown at A, being nailed

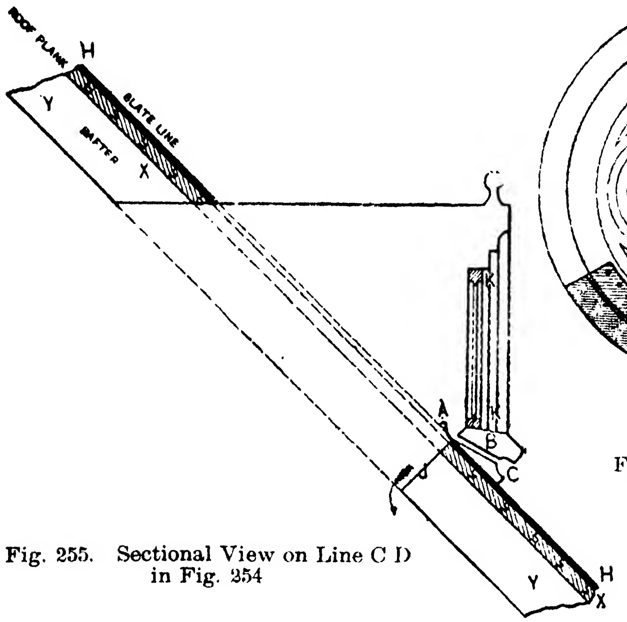


Fig. 255. Sectional View on Line C D in Fig. 254

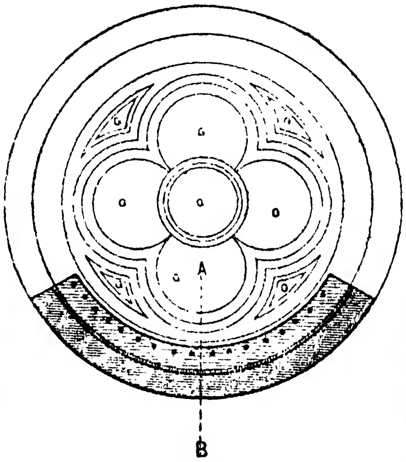


Fig. 257. Inside Elevation of Circular Window, Showing Condensation Gutter in Position

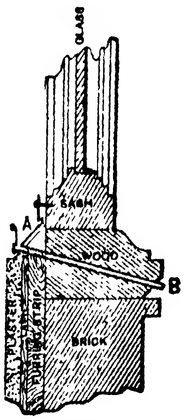


Fig. 258. Sectional View Through A B in Fig. 257

against the sash K. A tube in the center of the gutter was placed as shown at X in Fig. 254, and passing through the sill B projected over the cove molding C, as shown in Fig. 255. Fig. 256 is an enlarged view of part of Fig. 255, showing the manner of fastening the condensation gutter. Y Y represent the rafter, X X the roof planks and S S the slates. D is a wooden bracket nailed to the roof planks, on top of which the wooden sill C is placed.

After slating up to N, the metal dormer, with the flashing attached around and water tight to the sill, as shown by A B in Fig. 254, is placed over the wooden sill C and over the slates, as shown in Fig. 256. After the dormer is framed on the inside by the carpenter the wooden sash shown in Fig. 256 is placed into the metal dormer from the outside, against the flange bent up on the metal sill, and nailed as shown at B. This flange prevents the rain, when striking against the dormer, from running or soaking to the inside, as was first supposed to be the case, before the condensed moisture was thought of. The sash being fastened, the condensation gutter is formed corresponding to the shape of the inside sill, as shown by F J in Fig. 256. The length being obtained, a head is soldered at each end and a hole punched in the center of the gutter, and at its deepest point, correspond-

ing in size to the tube used, which is usually $\frac{3}{4}$-inch diameter. A wired edge is placed at the top of the gutter, as shown at F. The gutter is placed temporarily in its proper position and a mark made where the tube will pass through the wooden sill C. Then, taking away the gutter, bore a hole through the wooden sill C with an auger, and, using a small sharp chisel and hammer, cut a round hole through the metal sill, as shown at H. Set the gutter again in its proper position, placing a bedding of white lead between the upper flange J of the gutter and the bottom of the sash. The flange J is nailed every $\frac{1}{2}$ inch with small tinned tacks, thereby making a good water-tight joint. The metal tube is now placed through the hole in the metal sill H and through the wooden sill C, from the outside, until it projects about $\frac{1}{3}$ inch over the inside of the gutter; then with a small hammer a flange is turned on the tube and against the gutter, and soldered water-tight, which completes the job.

The same method, shown in Fig. 256, would be employed on the chapel windows, with the exception that the latter are usually all made of wood. A case in mind is a condensation gutter which was made for a circular window, 8 feet in diameter, over a choir in a church. The gutter was made to correspond to one-third of the circle, as shown by the heavy lines in Fig. 257, and nailed along the edge of the sash, as shown, using white lead, as before explained, to obtain a water-tight joint. G G G, etc., in Fig. 257, indicate the glass. The method used to fasten the gutter and to connect the tube is the same as shown and described in connection with Fig. 256. Fig. 258 is a sectional view, taken on the line A B in Fig. 257, and shows the method of flanging the bottom of the gutter at A. The tube is shown at B. Care should be taken to solder water-tight and heavily the two upright strips of the gutter to the bottom, shown at A in Fig. 258.

A GLASS CORNICE

A residence of unusually attractive architecture, with a detail of interest in the use of plate glass at the eaves, was recently erected. In order to obtain the effect of an overhanging roof as a conspicuous feature of the exterior design of the house and yet not obstruct the light desired for the second floor rooms, it was arranged to use glass all around the eaves. As the owner resolutely demanded maximum light for the second floor rooms and as compliance with this desire would require either that the roof be raised or the cornice be narrowed, the use of glass was decided on, as stated, without departing from the original design.

On account of the unusual character of the structure the accompanying drawings, Fig. 259, have accordingly been prepared. It will be noted that the glass is carried on extended or false rafters, which are 4×7-in. timbers spaced 20 in. on centers. The glass covers about the last 2 ft. of the roof, which is otherwise covered

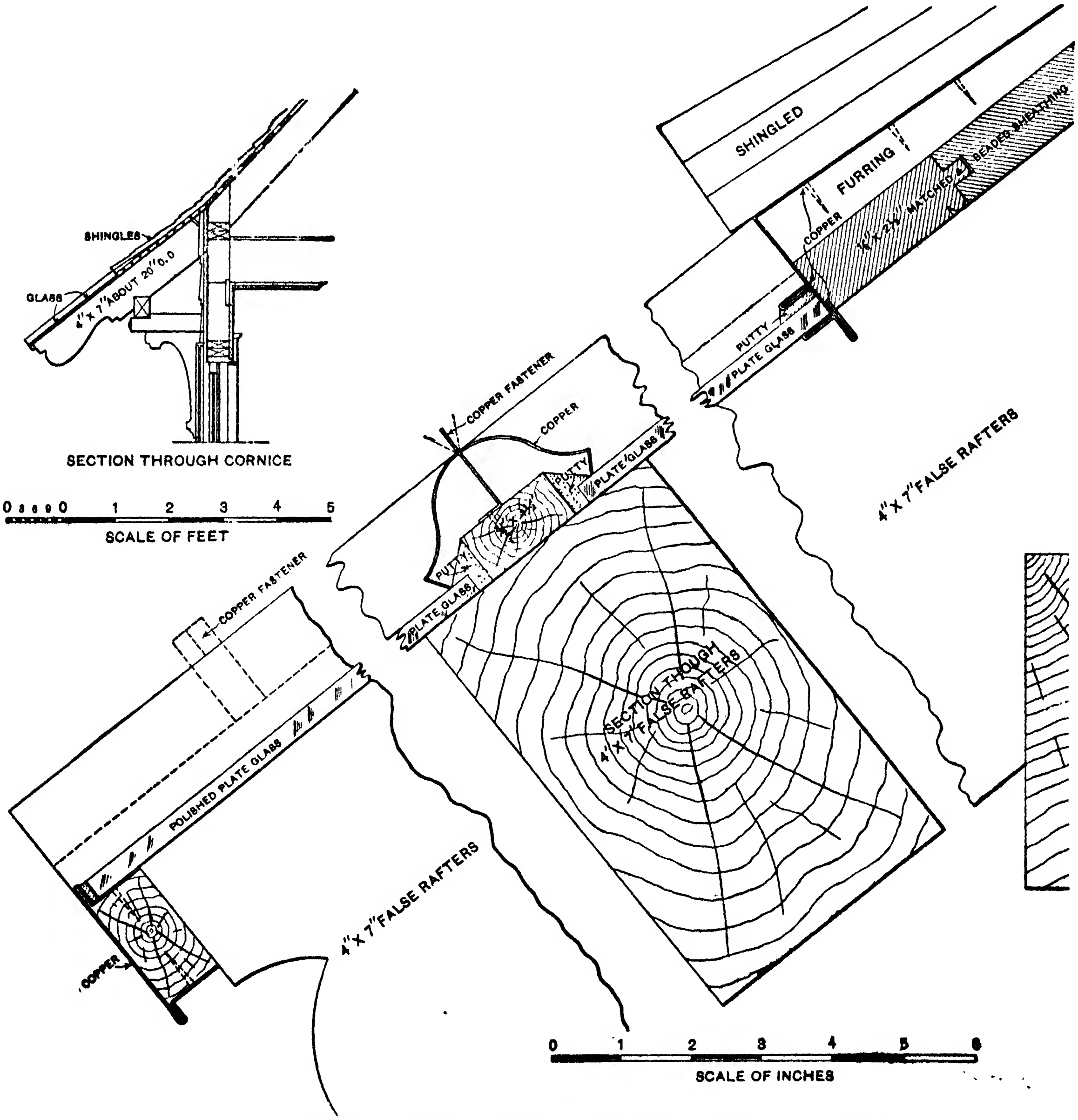


Fig. 259. Details of the Glass Cornice and the Copper Work

with wood shingles. The glass is provided in plates about ¼ in. thick, 2 ft. in the direction of the rafters and about 18 in. wide. This size glass plates was felt fully strong enough for such loads as they would have to carry, and being polished

plate glass, the highly polished surface was counted on to keep the glass free from accumulations of dirt. The use of the glass has made the cornice one of the unusually striking features of the house. Instead of detracting from the appearance the cornice has given it an individuality at a relatively small additional cost.

The drawings show the copper work at the head of each glass plate formed in the usual way to hold the inclined glass plates with a putty filling as shown. The copper is nailed to furring strips underneath the three courses of shingles forming the base of the shingle roof. The glass is supported at the outer end of the false rafters by a copper curb formed and nailed to a $\frac{7}{8} \times 1\frac{3}{4}$-in. stringer as indicated. The joint over each of the false rafters is also shown. A wood strip $\frac{3}{4} \times 1\frac{1}{2}$ in. is fastened to the top of the false rafter. Between this and the glass plate on each side is allowed space for the putty joint. This whole construction over the center of each false rafter is protected by the copper rib or cap extending the length of the overhanging cornice and adding to the architectural effect of the whole construction. This copper cap is provided with slits at suitable intervals, and the copper fastening strip, nailed to the $\frac{3}{4} \times 1\frac{1}{2}$-in. wood strip, extends through the top of the cap, this strip being slit in a usual way, so that it can be pulled over in opposite directions on the cap as the drawings indicate.

A SHEET METAL CONSERVATORY FRONT

In Fig. 260 is shown the elevation, section and plan of a sheet metal conservatory front, constructed on wood framing, between the sill and cornice. The paneled base and main cornice are fastened to the brick walls as indicated in the section, the piers H and J in plan and H^1 and J^1 in elevation also being brick.

The aim of this article is to show how the water-tight joints are made between the metal sills and mullions and the wooden window sashes. The details showing the constructions of the various parts are drawn to a scale of 1 in. to the foot in Figs. 261 and 263, inclusive.

The section through A B in Fig. 260 is shown in Fig. 261 in which A is the metal sill set upon the rough blocking B, with a flange turned upward at *a*. Before the wooden sill D is set in position a grove is cut into the bottom of the sill at *a*, after which the sill is then set over the metal flange *a*, making a tight joint and preventing water from backing up on the inside.

Provisions are made on the sill D to receive the copper gutter *b*, which is nailed in white lead, using brass or copper nails along the top of the sill at *e*. This

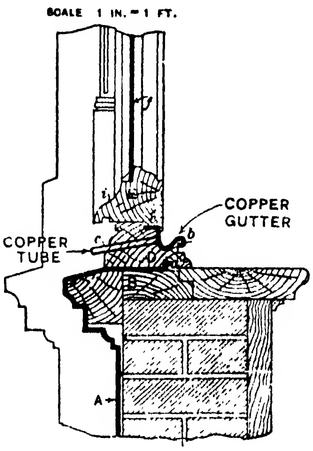


Fig. 261. Section Through A B of Fig. 260

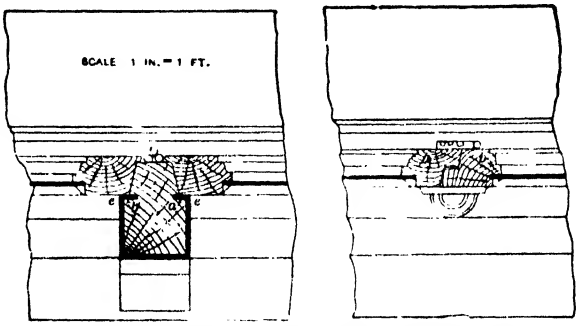


Fig. 263. Section Through E F of Fig. 260

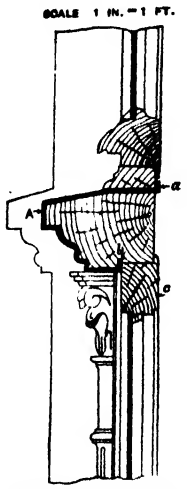


Fig. 262. Section Through C D of Fig. 260

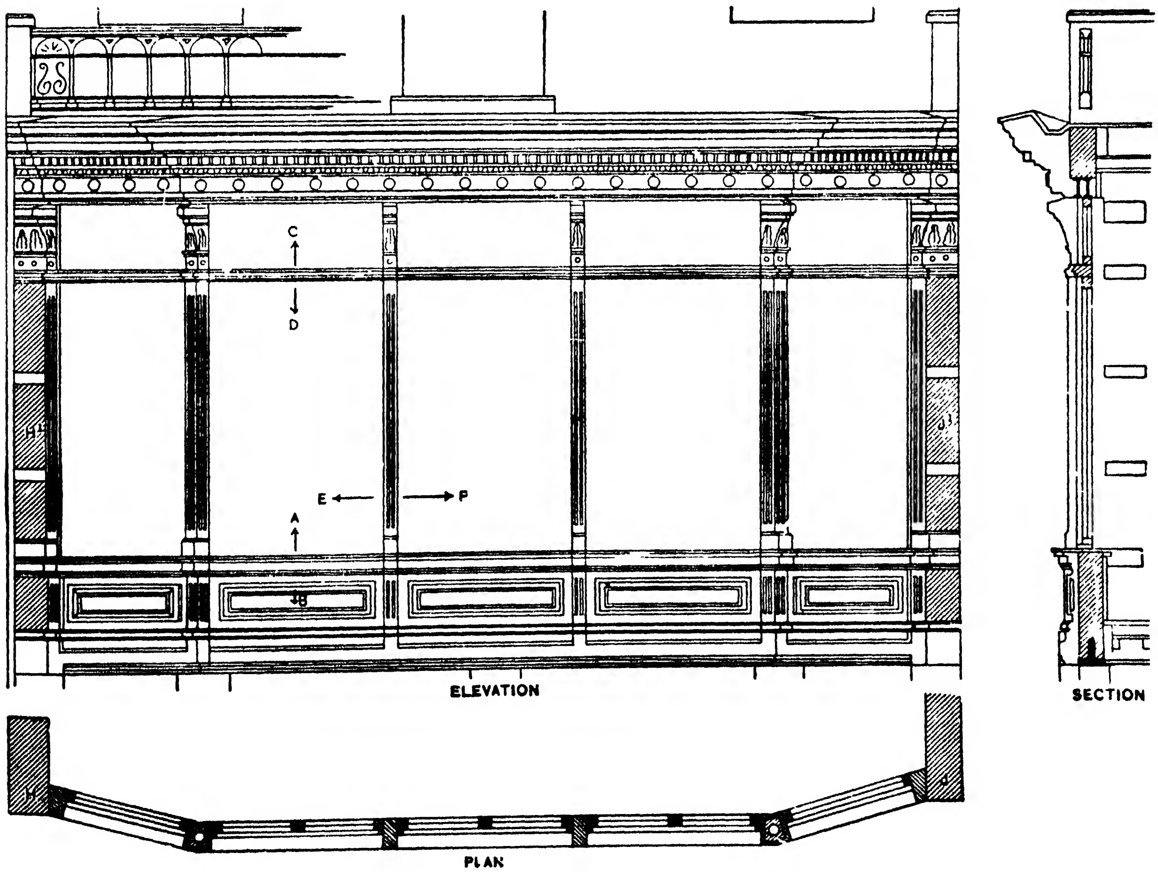


Fig. 260. Elevation, Section and Plan of a Sheet Metal Conservatory Front

gutter *b* is placed to catch the condensation which forms on the inside of the glass *f* when the warm air comes in contact with the surface of the cold glass in winter, and it is carried outside by means of copper tubing *c* placed at intervals along the gutter. It will be noticed that the windows are hinged at *c* in Fig. 263, and for this reason the sill E in Fig. 261 has a drip as indicated at *i* to prevent the water from following the bottom of the sill to the inside.

The section through C D in Fig. 260 is shown in Fig. 262, in which the mullion A flanges up behind the sill at *a*, over which the wooden sill of the transom is set, and prevents the water from backing up on the inside. A flange is also turned up on the bottom of the mullion at *b*, against which the top of the window frame *c* closes.

A section through E F in Fig. 260 is given in Fig. 263. This shows the vertical mullion flanged inward at *a* and *b*. The window frames being hinged at *c*, close against the metal work at *e* and *e*, and lock together at the center, as shown by *a* and *b*. In doing work of this kind it is important that the carpenter and sheet metal worker work hand in hand, each having similar details, which arrangement insures a first-class job.

SECTION VIII

(Pages 901-1,012)

CORNICE PATTERN LAYOUTS

Practical Sheet Metal Work and Demonstrated Patterns

KINDS OF PROJECTIONS

As the principles of pattern cutting are based on geometry and projection and as there are several kinds of projections, and as these are mentioned but not explained, the explanations are here given. It has been said that the difference between orthographic and perspective projections is that the former shows an object as it *is*, while the latter presents it as it *looks*. In the orthographic pro-

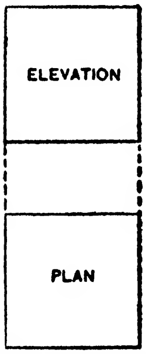


Fig. 1. Orthographic Projection of a Cube

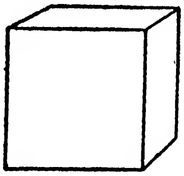


Fig. 2. Perspective View of a Cube

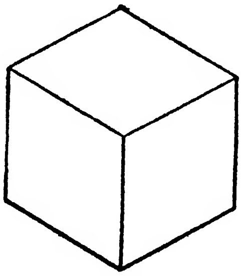


Fig. 3. Isometric Projection of a Cube

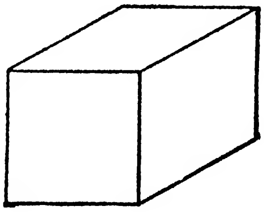


Fig. 4. Cavalier Projection of a Cube

jection the eye is placed at an infinite distance from the object, and the points on the object are projected on a horizontal and also on a vertical plane, the horizontal projection being commonly called the plan, and the vertical the elevation. Fig. 1 is an orthographic drawing of a cube.

In perspective the eye is brought within visible distance of the object, and the object is reproduced as it appears to the eye from that viewpoint. The best example of perspective is a photograph. Fig. 2 shows the cube put into perspective.

The word isometric means equal measures. In an isometric projection three directions, or axes, are first drawn from a common center or origin, as it is called. One of these is drawn vertically, and the other two are separated from it 120 degrees,

one to the right and the other to the left. All vertical lines are drawn vertically, horizontal lines parallel to the picture plane are drawn parallel to one of the other axes, while lines perpendicular to the picture plane are drawn parallel to the remaining axis. All lines that are in reality vertical, horizontal and parallel to the picture plane, or perpendicular to it, are measured or scaled their full length. There is no foreshortening, as in perspective. Positions of other lines can be found by locating points on the lines by means of triangles. Circles are generally projected as ellipses. Isometric drawings have an advantage over orthographic in that they present a picture resembling a perspective view from which measurements may be directly made from the principal lines, thus being very useful as working drawings. Fig. 3 shows the isometric projection of a cube. On this it will be noticed that each of the lines is of the same length.

Cavalier projections are not extensively used. They answer much the same purpose as the isometric. Fig. 4 illustrates the cube in cavalier projection. From this it will be seen that lines parallel to the picture plane are represented in their true length. Lines perpendicular to the picture plane are represented in their true length, and are all shown at the same angle in the same drawing, although a different angle may be used in every drawing. The theory of this is that these lines vanish at a point infinitely distant from the object, and the direction of this point may be located at the will of the draftsman, provided he keeps it back of the picture plane.

In a cavalier projection circles parallel to the picture plane are projected as circles.

PATTERN FOR A SIX POINTED STAR

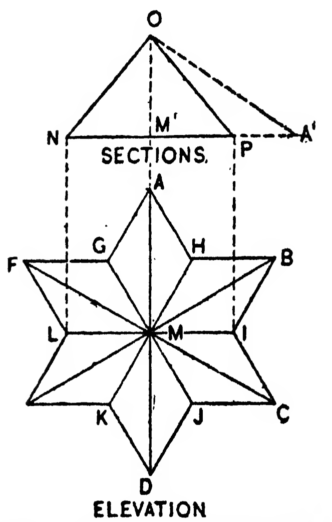


Fig. 5. Elevation and Sections

In Fig. 5 is shown the elevation and sections of the star, in which A B C D E F G is the elevation and N O P the true section on the line L I in the elevation. A true section will also be necessary on the line M A in elevation. Take the distance M A and place it as shown from M^1 to A^1, and draw a line from A^1 to O, which is the true length on M

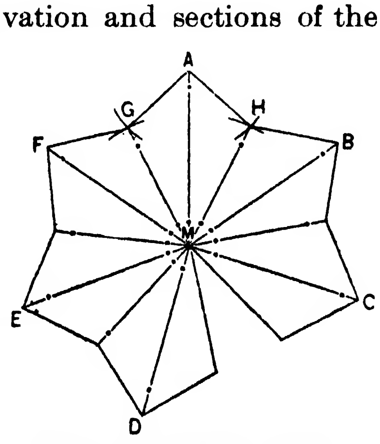


Fig. 6. The Pattern Shape

A in elevation. For the pattern proceed as follows: Draw any line on Fig. 6, as A M, equal to A^1 O in Fig. 5. Now with radii equal to A G or A H and with A in Fig. 6 as a center describe the arcs G and H. Then with O P in Fig. 5 as radius and M in Fig. 6 as center intersect the arcs G and H at G and H. Draw lines from M to G to A to H to M, which will be the pattern for one point of the star. If the pattern is desired in one piece join six of these points, as shown by D E F A B C, and bend on the lines shown to fit the outline in elevation.

PATTERN FOR BRACKET FACE

To obtain the pattern for the face of the bracket shown in Fig. 7, in which A B C D shows the front of the bracket and E F G the side, the portion for which the pattern is required being indicated by H I J K L in front and M N O P in side view. In Fig. 8 H I J K L is an enlarged reproduction of similar letters in Fig. 7 and is called the plan in Fig. 8, and M N O P is the side-elevation, being an enlarged reproduction of similar letters in Fig. 7. The problem is a tapering

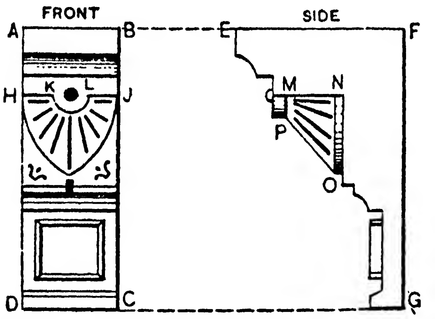


Fig. 7. Front and Side View of Bracket

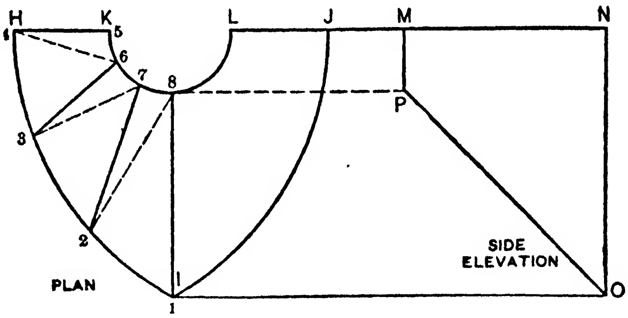


Fig. 8. Obtaining Measurements for Triangles

article the base being indicated by the half plan H I J in Fig. 8 and top by the semicircle K L, the side view or hight being indicated by M N O P.

The problem will be solved by triangulation and the first step will be to obtain a diagram of triangles, as shown in Fig. 9, for which proceed as follows: Divide one-half of the plan H I in Fig. 8, as shown by the small figures 1 to 4. In similar manner divide one-half of the semicircle K L into the same number of spaces, as shown from 5 to 8. Now connect solid lines from 1 to 8, 2 to 7, 3 to 6 and 4 to 5, and dotted lines from 2 to 8, 3 to 7 and 4 to 6. Then will these solid and dotted lines represent the bases of the triangles, while M N in side elevation will represent the altitude or hight.

In Fig. 9 draw any horizontal line, as C D, equal in length to M N in Fig. 8. At right angles to C D in Fig. 9 and through D draw the line D 1 and D 8 indefi-

nitely, as shown. Now take the various lengths of the solid lines 8 1, 7 2, 6 3 and 5 4 in plan in Fig. 8 and place them on the line D 1 in Fig. 9, measuring in each instance from D, thus obtaining the points 1, 2, 3 and 4. From these points draw lines to the apex C. Then will these solid lines represent the actual distances on similar lines in plan in Fig. 8 when measured on the finished article. Proceed in similar manner for the triangles on dotted lines; take the various distances of the lines 2 8, 3 7 and 4 6 and place them on the line D 8 in Fig. 9, measuring in every instance from the point D; then draw lines from 6, 7 and 8 to the apex C. Then will these dotted lines represent actual lengths on dotted lines of similar numbers in plan in Fig. 8.

For the pattern shape proceed as is shown in Fig. 10. Draw any vertical line, as 1 8, equal in length to P O in Fig. 8 or C 1 in Fig. 9. With 1 2 in plan, Fig. 8, as radius and 1 in Fig. 10 as center describe the arc 2. Then with C 8 in Fig. 9 as radius and 8 in Fig. 10 as center describe an arc intersecting the arc as shown.

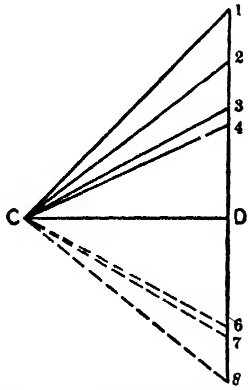


Fig. 9. Triangles for Pattern

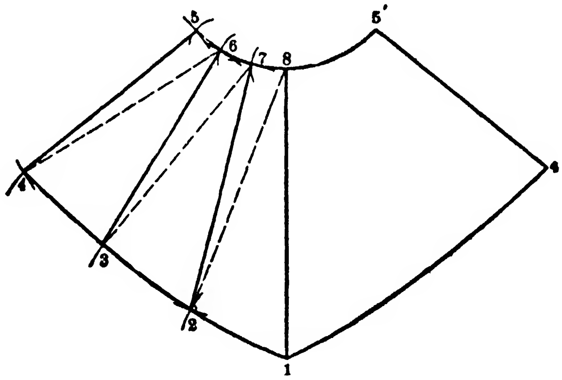


Fig. 10. The Pattern Shape

With 8 7 in plan as radius and 8 in Fig. 10 as center describe the arc 7, and with C 2, Fig. 9, as radius and 2 in Fig. 10 as center describe an arc intersecting arc 7. Proceed in this manner, using alternately as radii the divisions on the plan H I in Fig. 8, the length of the dotted lines in Fig. 9, the divisions in the semicircle in plan K L in Fig. 8 and the length of the solid lines in Fig. 9, until the line 4 5 in pattern has been obtained. Trace a line through intersections thus obtained and then will 1 4 5 8 be the pattern. Trace the other half opposite the line 1 8, as shown by 4′ 5′. Then will 1 4 5 8 5′ 4′ 1 be the desired pattern.

Referring to the front and side views in Fig. 7, it will be noticed that incised work is cut into the pattern. This is accomplished by drawing the opening on the pattern, in Fig. 10, and cutting out the incisions, then stripping to the required depth and soldering the portion cut out to the back of the sink strip.

OBLIQUE INTERSECTION OF HORIZONTAL MOLDING WITH ROOF

In the accompanying diagram, Fig. 11, A B C D represents the elevation of molding, the profile of which is shown at S, and A E the pitch of the roof against

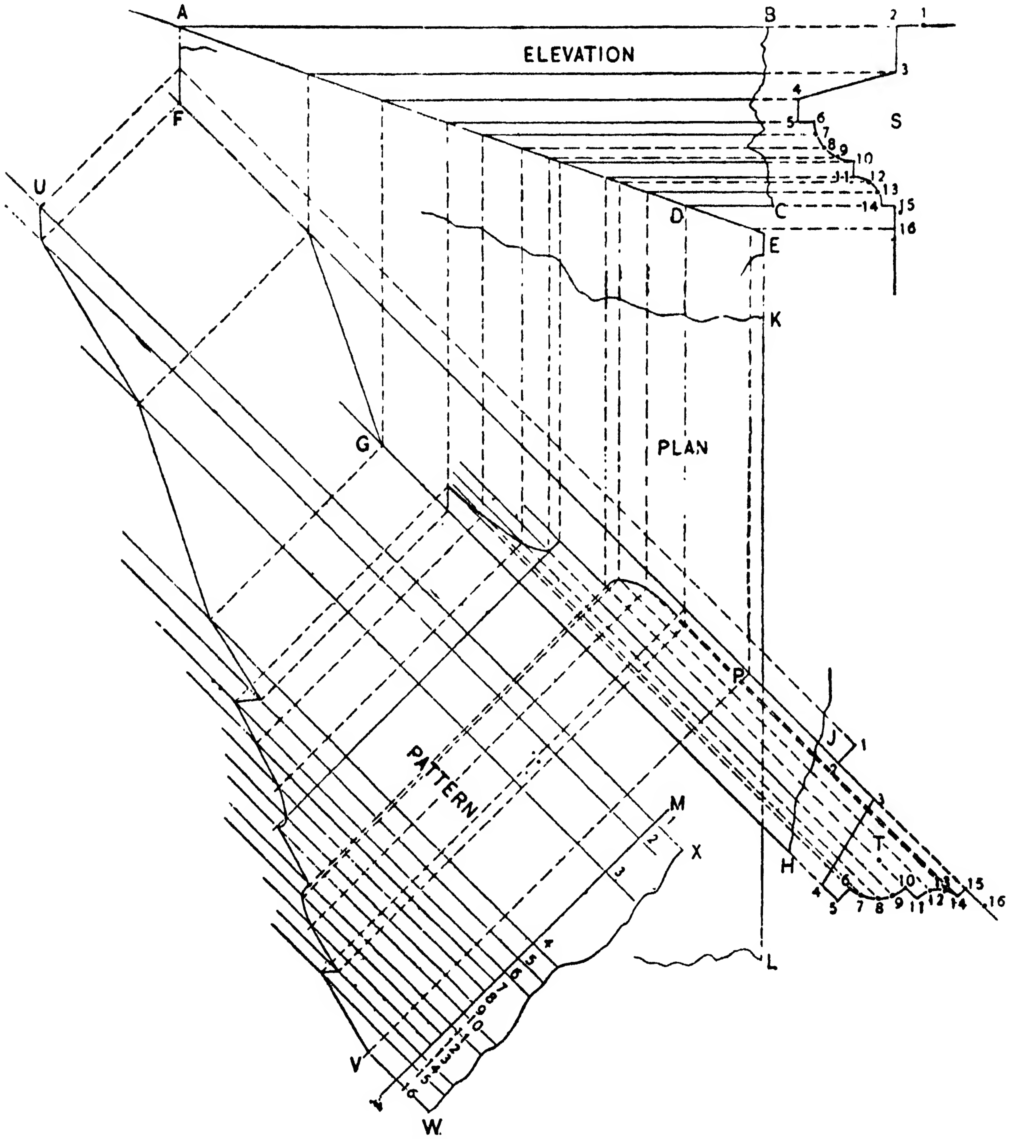


Fig. 11. Elevation, Plan and Pattern

which the molding is required to miter; while F G H J, the plan of the molding, shows that it is placed at an angle of 45 degrees with K L, representing the eaves of the roof or any horizontal line drawn upon the roof surface.

Before the pattern can be developed a plan of the intersection of the mold with the roof surface must be obtained. Therefore, first draw a duplicate of the profile S in the plan, as shown at T, placing its vertical lines at the required angle with K L and its face toward the front of the plan corresponding with the elevation, and divide the curved portions of both profiles into the same number of equal parts respectively, as shown by the small figures. From the several points and angles in profile T carry lines at the required angle with K L indefinitely, as shown, and from the points in profile S carry lines horizontally, intersecting the roof line, as shown between A and D. Finally, from the several points of intersection just obtained drop lines vertically into the plan, cutting lines of corresponding number. Lines connecting the adjacent points of intersection, as shown from F to P, will give the required plan of the intersection or miter.

To obtain the pattern a stretchout of the profile may now be set off on any line, as M N, drawn at right angles to the lines of the molding in plan, as shown by the small figures on M N. From the points so obtained on M N draw the usual measuring lines parallel to F J indefinitely, and from the several points in the plan of the miter F G P project lines at right angles to F J, cutting measuring lines of corresponding number, as shown between U and V. A line traced through the several points of intersection will give the required miter. The complete pattern is shown by U V W X, which may be extended beyond W X to suit convenience.

PATTERN FOR A HEAD TO FILL THE END OF A CORNICE CUT OFF OBLIQUELY

In the accompanying illustration, Fig. 12, is shown a problem presented for solution, together with the method of laying out the required end piece. In the sketch the profile of the cornice is drawn in the manner shown at B, which position would be correct were the view an elevation instead of a plan. As the profile shown is that usually employed in a crown mold, it is clear that it should occupy the position shown at A, since the points 1 and 2, being its points of extreme projection, should be on the line F G, which is the line of extreme projection from the wall in plan. Attention is called to this because a correct drawing is the first essential to a correct result. Failure or inability to develop the pattern results in many instances from the fact that a drawing has not been first made in which the required conditions are correctly shown.

There is also some doubt implied in the sketch as to whether the angle in the wall at which the cornice ends is an interior or an exterior angle. It would seem rather to show an interior angle, but since if it were an interior angle the end of the cornice would come against the wall on the other side of the angle, and would therefore scarcely require a full end or "head," therefore, it is assumed, and a drawing made showing a cornice at the end of a wall terminating with an exterior angle. In either case the method employed is the same. Care must be taken, however, to see that the profile is correctly placed — that is, with the points 0 and 14 at the wall line, and the points 1 and 2 at the line of extreme projection. Therefore, if C F G were the wall line instead of C D E, as shown, and D E were the line of extreme projection, instead of F G, the profile should be turned over so that the points 0 and 1 would change position with each other.

Considering, then, that C D E is a plan of the wall, and that F G is the line of extreme projection of the cornice, first extend the line C D, as shown, by D F,

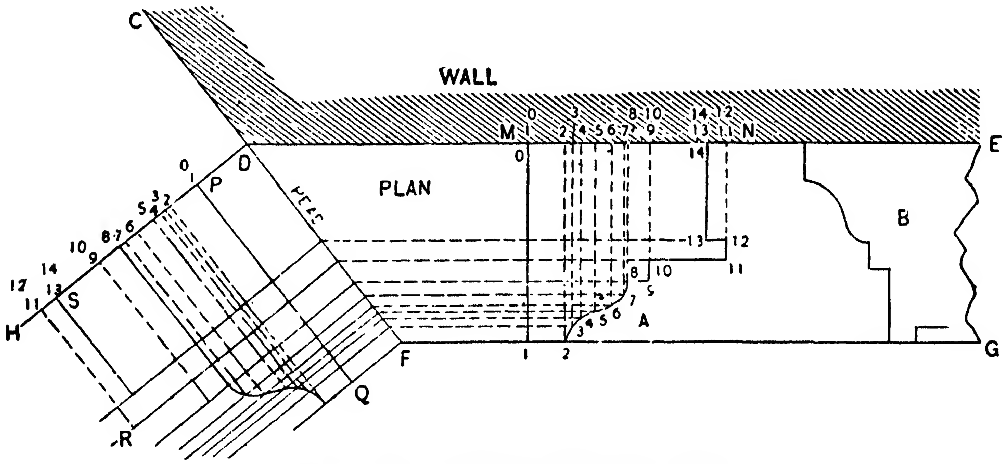


Fig. 12. Plan, Profile and Required Head.

this line showing the position in plan of the end or "head" required to fill the opening produced by the oblique termination of the cornice. Divide the curved portions of the profile into any convenient number of spaces and number all points and angles of the profile, as shown by the small figures on profile A. From each of the points project lines parallel to D E, cutting the line D F, as shown, and from the several points of intersection on D F carry lines at right angles to the same indefinitely, as shown at the left. From the several points in profile A also carry lines at right angles to D E, cutting the same as shown by the small figures between M and N; corresponding with those of the profile. Now transfer the points in M N to the line D H, seeing that each point maintains the same relative distance from all of the other points, as on M N; and from each of the points on D H

project lines at right angles to the same cutting lines of corresponding number previously drawn from D F. A line traced through the points of intersection, as shown by O P R S, will be the shape of the required end piece.

The miter of the cornice moldings to fit against the end piece is an ordinary butt miter, of which D E is the miter line, and the same set of points may be used with convenience in cutting both pieces.

LAYING OUT PATTERNS DIRECT ON THE METAL

When it is desired to carry the miter patterns direct on to the metal from the drawings, the short rule employed in shops is as follows: Let E, Fig. 13, the given profile, be divided into equal spaces, as shown by the small figures from 1 to 8.

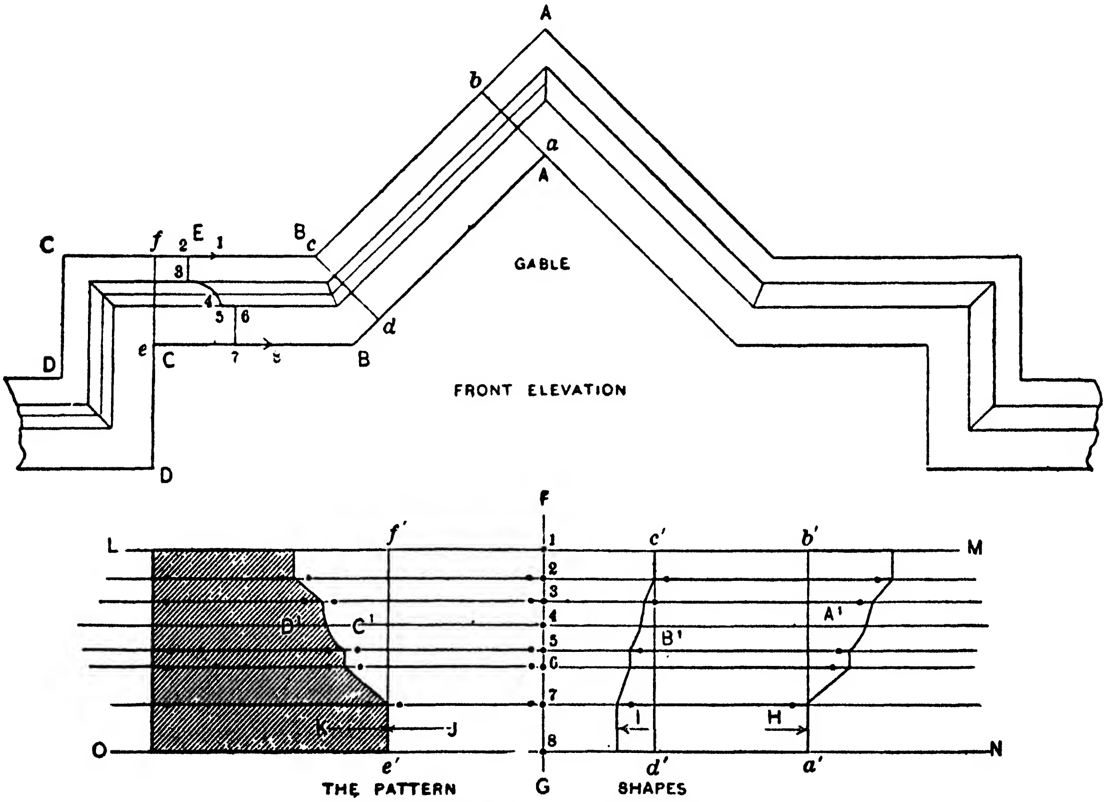


Fig. 13. Elevation, Profile and Patterns

Through these small figures and parallel to C B draw lines intersecting the miter lines B B and C C. From the intersections on C C and parallel to C D draw lines intersecting the miter line D D. In similar manner from the intersections on the miter line B B draw lines parallel to B A, intersecting the gable miter line A A.

Now, at right angles to A B and from point *a* draw the line *a b*, and from the point *c* draw the line *c d*. In the same manner at right angles to B C and from point *e* draw the line *e f*.

Let L M N O represent a sheet of metal of the required width, upon which erect the vertical line F G, upon which place the stretchout of the mold E, as shown by the small figures 1 to 8 on F G. Through these figures draw lines parallel to L M or N O on the sheet of metal. At right angles to N O draw the line *a' b'*. Now, measuring with the dividers in every instance, from the line *a b* in elevation take the lengths of the various lines intersecting the miter line A A and place them in the pattern, measuring in each instance from the line *a' b'* on lines having similar numbers; trace a line through points thus obtained, resulting in the miter cut A^1, which will be the miter pattern on the line A A in elevation. In similar manner at right angles to N O erect the vertical line *c' d'*. Now take the various lengths from the line *c d* to the miter line B B in elevation and place them on lines having similar numbers in the pattern, measuring from the lines *c' d'*. Trace a line through points thus obtained, resulting in the pattern B^1, which will be the miter pattern on the miter line B B in elevation. Finally at right angles to N O erect the line *e' f'*, from which place the various distances on the various numbered lines obtained by measuring from the line *e f* in elevation to the miter line C C on similar numbered lines. Trace a line through points thus obtained in the pattern; then will C^1 be the miter pattern on the miter line C C in elevation, while the reverse cut, or the shaded part D^1 in pattern, is the miter pattern on the miter line D D in elevation. This completes the entire set of patterns for A, B, C and D. In practice these miter patterns are cut out of metal seperately about 8 inches long. Thus the pattern A^1 and B^1 would be on one piece of metal, while C^1 and D^1 would be separate.

When laying out the length of the gable molding A B measure from H to I in the patterns, first marking on the metal the miter cut A^1, then moving the pattern to the desired length from H to I, equal to A B in elevation, and marking the pattern B^1. When getting out the horizontal molding B C in elevation measure from J to I in the patterns, first marking the miter pattern C^1 on the sheet, then reverse the pattern B^1, making the distance from J to I equal to B C in elevation, then marking the pattern B^1. For the vertical molding C D measure from J to K the length of C D; in other words, first mark the miter pattern C^1 on the metal, then reverse D^1, making the distance from J to K equal to C D. For the lower horizontal molding use the pattern D^1, measuring from the point K.

PATTERNS FOR REDUCED MITER

This article treats on the method of how to get the patterns for a return miter for a bay window, or the best way to make a finish at the point B in plan in accompanying illustration, Fig. 14. The distance from B to C on the finished wall is 8½

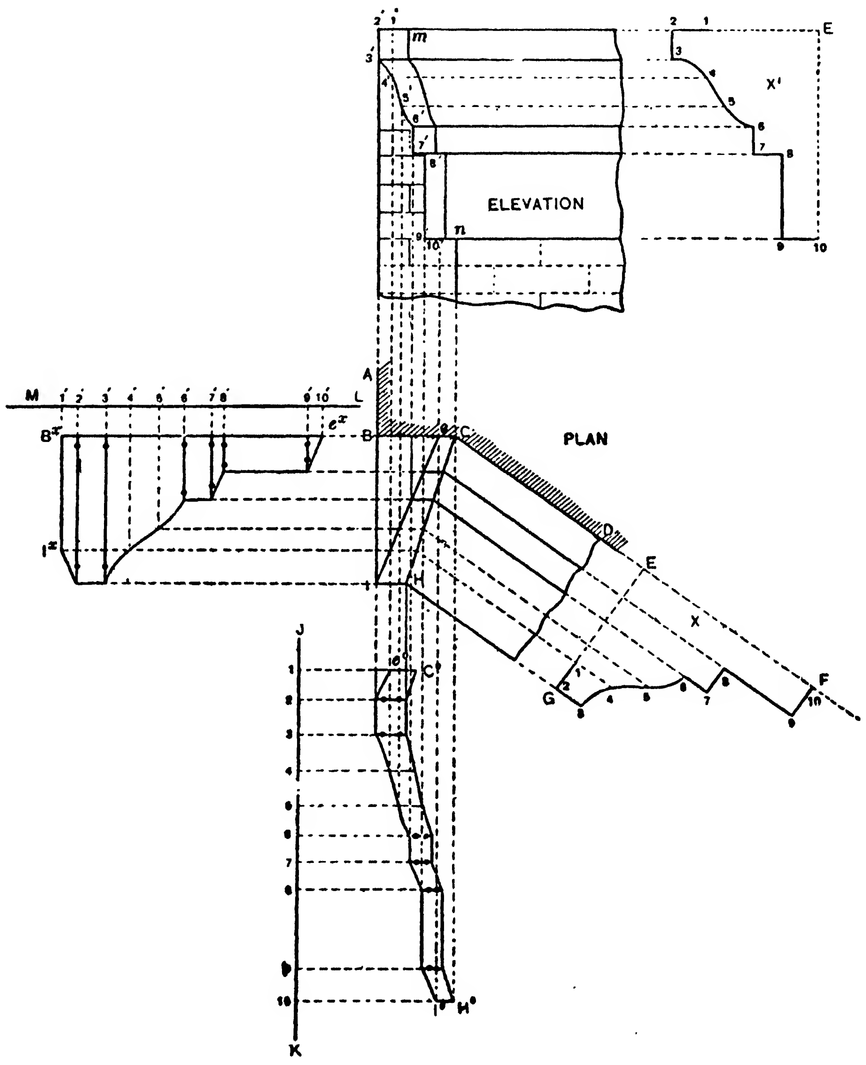


Fig. 14. Elevation, Plan, Profile and Pattern

inches, while the projection of the molding from G to E is 18 inches, and would naturally bring the return miter 9½ inches outside of the wall line A B.

In a case of this kind a reduced miter is used, which is obtained as follows: Let A B C D represent the part plan of the bay window. In its proper position draw the profile of the mold, no matter what its shape may be, as shown by E F G,

which divide into equal spaces, shown by 1 to 10. Bisect the angle B C D in plan. Where the bisecting line meets the line drawn from 2 in the profile X parallel to C D, call the point H. From H draw a line parallel to C B, meeting the wall line A B, extended at I. If desired, the projection of the reduced return miter could be made equal to B C, but this would not make a neat appearance. Therefore, make the distance C *e* in plan equal to 2 inches, and draw a line from *e* to I. Then will *e* B I be the plan view of the reduced return miter.

From the numbers in X draw lines parallel to C D, cutting the miter line C H, as shown, from which points parallel to B C draw lines intersecting I *e*, as shown. Take a tracing of the profile X and place it in the position shown by X^1. From the various numbers in X^1 draw horizontal lines, which intersect by lines drawn from similar intersections on *e* I in plan, at right angles to B C, resulting in the intersections 1′ to 10′ in elevation. Through these trace a line as shown. Then will 1′ 10′ in elevation represent the true profile of the reduced return on B *e* in plan and *m n* in elevation the miter line on C H in plan. To obtain this miter line *m n* project from the various intersections on C H in plan vertical lines cutting similar horizontal lines in elevation, the lines being omitted in the illustration to avoid a confusion of lines.

For the pattern for *e* C H I in plan draw any line, as J K, at right angles to I H, upon which place the stretchout of X, as shown by similar numbers. Through these small figures draw lines at right angles to J K, which intersect by lines drawn from similar numbered intersections on the miter lines *e* I and H C at right angles to I H, thus obtaining the intersections e° to I° and H° to C° respectively. Trace a line through points thus obtained, then will e° C° H° I° be the pattern for that part shown by similar letters in plan. The reverse of the cut C° H° will also answer for C H on the piece H C D in plan. For the pattern for the reduced return draw any line as L M, parallel to B C, and proceed in a similar way, obtaining I^x B^x e^x, the pattern for the portion shown by I B *e* in plan.

PATTERN FOR GABLE AND HORIZONTAL MOLDINGS HAVING DIFFERENT PROFILES

To obtain the patterns for two moldings of different profiles forming a miter, as a gable molding meeting a horizontal molding as shown in Fig. 15, in which A B C D represents the part elevation of the gable, E being the given profile of the gable mold and F the desired profile of the horizontal mold.

The first step is to divide either profile (in this case E) into equal spaces, as shown by the small figures 1 to 12 in E. Take a tracing of E with the various

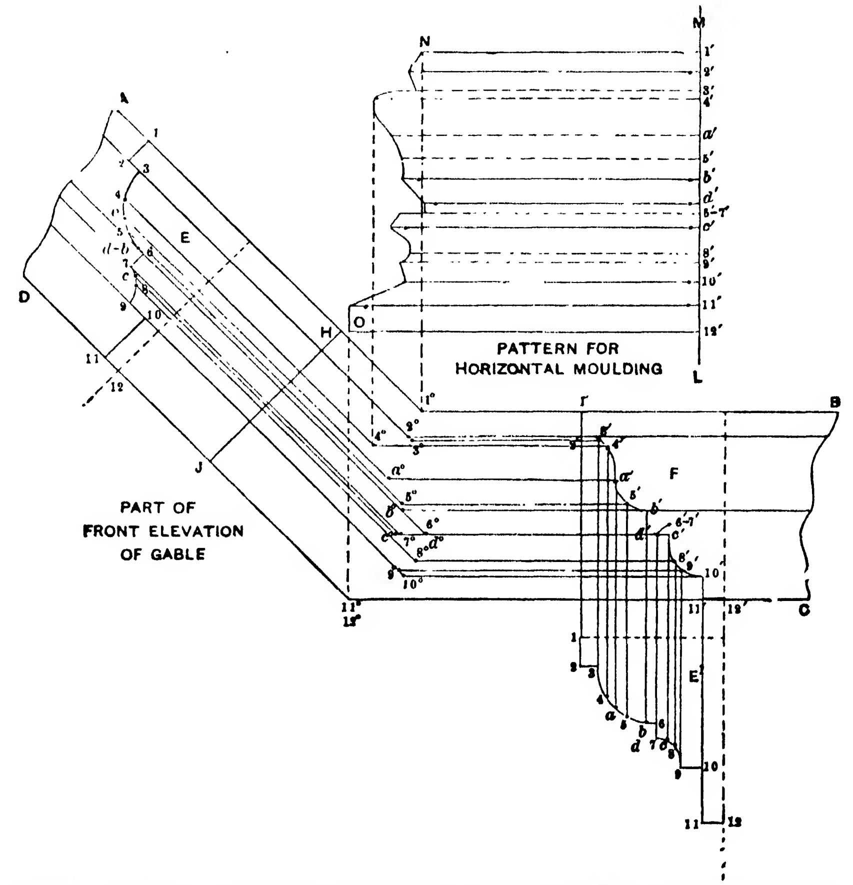


Fig. 15. Obtaining Points of Intersections and Pattern for Horizontal Molding

points of intersections and place the tracing with its bottom line on the vertical dotted line extended through 12′ in F, the position of the tracing being marked E^1.

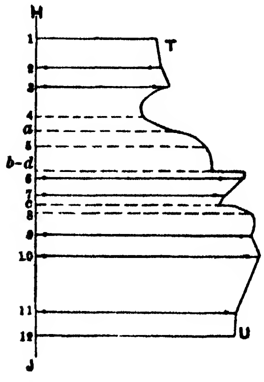


Fig. 16. Pattern for Gable Molding

From the points 1 to 12 erect vertical lines cutting the profile F from 1′ to 12′. Establish at pleasure the point *a*′, and from this point and also from *b*′, *d*′ and *c*′ drop lines intersecting E^1 at *a*, *b*, *d* and *c*. Now, from the various points of intersections in the profile F, parallel to the lines of the horizontal molding, draw lines as shown, which intersect with lines drawn parallel to the gable molding, from similar intersections in the profile E, and resulting in the points of intersections shown from 1° to 12°.

For the pattern for the horizontal mold take the stretchout of F and place it on the vertical line L M, as shown. Draw

the usual measuring lines, which intersect by lines drawn from similar intersections 1° to 12° at right angles to 1° B. Then will N $1'$ $12'$ O be the desired pattern.

For the pattern for the gable mold take the stretchout of E or E^1 and place it on the vertical line H J in Fig. 16, and draw the usual measuring lines.

At right angles to the gable mold in Fig. 15 draw any line, as H J. Measuring from this line, take the various distances to points 1° to 12° and place them on similar lines in Fig. 16, also measuring from the line H J. A line traced through points thus obtained, as T U 12 1, will be the desired pattern.

PATTERN FOR DISSIMILAR MOLDING

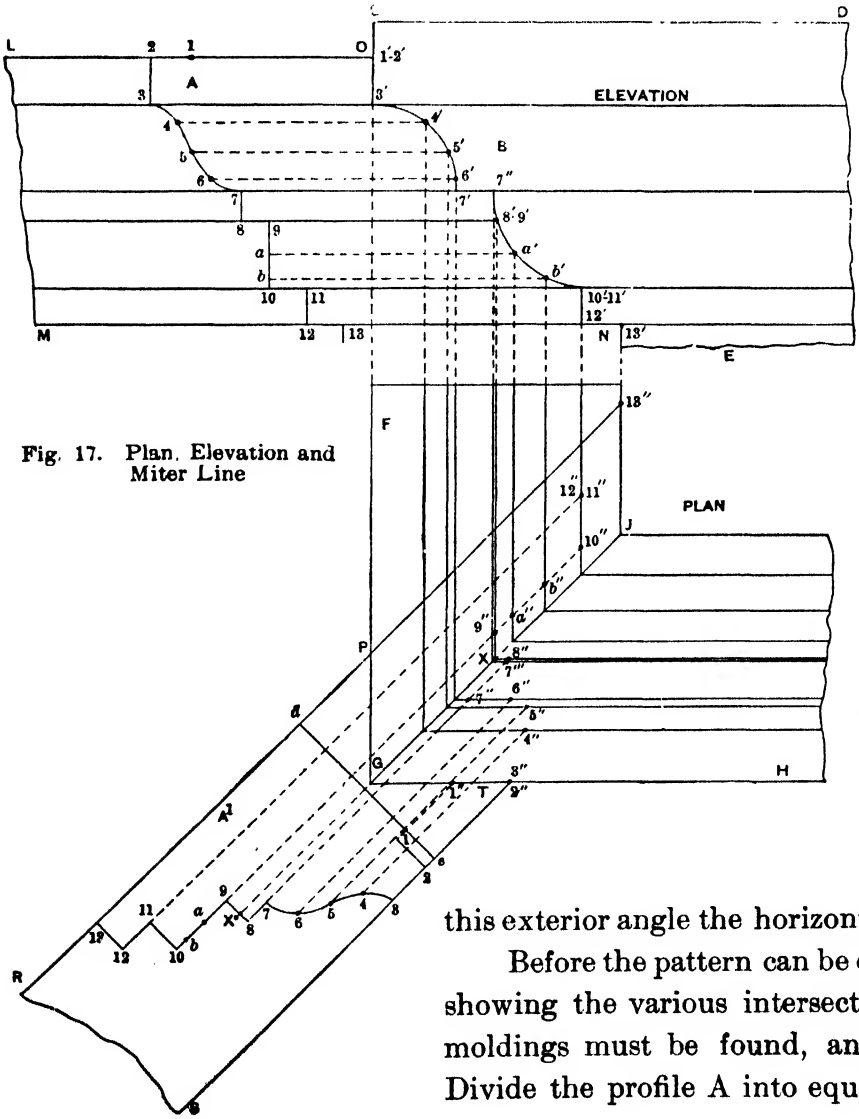


Fig. 17. Plan, Elevation and Miter Line

This problem treats on how to obtain the pattern for a horizontal molding intersecting a dissimilar molding at an exterior right angle, the horizontal molding being placed at an angle of 45 degrees in plan. In Fig. 17 let A represent the profile of the horizontal molding L O N M in elevation, shown in plan at an angle of 45 degrees by R P T S. B represents the profile of the molded corner shown in plan at right angle, F G H. Against this exterior angle the horizontal molding is to miter.

Before the pattern can be obtained the miter line showing the various intersections between the two moldings must be found, and is done as follows: Divide the profile A into equal spaces, as shown by

the small figures 1 to 13. From those intersections, parallel to M N, draw lines intersecting the profile B from 1′ to 13′. At pleasure locate two points between 9′ and 10′, as indicated by *a′* and *b′*, and from these points draw lines parallel to M N, intersecting 9 10 in A at *a* and *b*.

From the various intersections in B drop vertical lines, intersecting the miter line G J in plan, as shown, from which parallel to G H draw lines indefinitely. Take a tracing of A with the various divisions on it and place this in its proper position in plan, as shown by A^1. Through the various intersections in A^1, parallel to S T, draw lines intersecting similar lines in F G H as shown by the points of intersections 1″ to 13″. As the plane 8 9 in A^1 cuts the angle in plan shown by 8″ 9″, the corner X must be projected to the plane 8 9 in A^1, as shown by X°. A line traced through points 1″ to 13″ would be the miter line (but is here omitted).

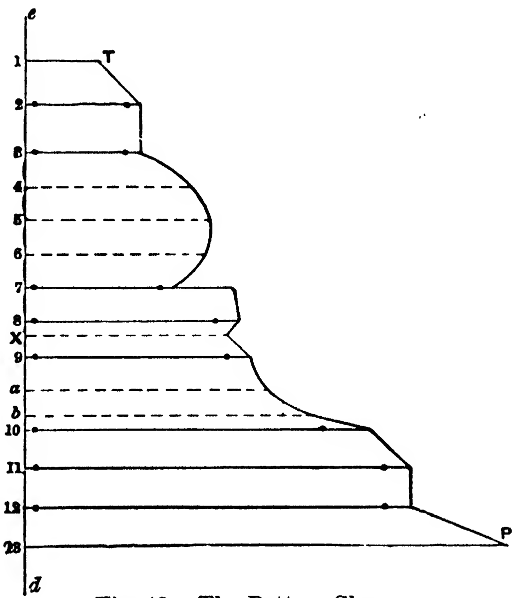


Fig. 18. The Pattern Shape

For the pattern for the horizontal mold A, or A^1, take the stretchout of A^1 and place it on the vertical line *e d* in Fig. 18, as shown, through which draw horizontal lines indefinitely. From any point as *d*, at right angles to R P in Fig. 17, draw the line *d e*. Measuring in each instance from the line *d e*, take the various distances to points 1″ to 13″ and place them on similar lines in Fig. 18, also measuring in each instance from the line *d e* resulting in the points of intersections shown. A line traced through these intersections, shown from T to P, will be the desired pattern.

PATTERNS FOR A SQUARE SHAFT MITERING ON A CONE

When a square shaft, the longitudinal axis of which, coincides with the axis of a right cone and miters with that cone, to find the patterns for the shaft and for the cone, proceed in this manner:

In Fig. 19 let A B C represent the elevation of the cone, corresponding to L M N O of the plan, and D E G F the elevation of the shaft, corresponding to P R T S of the plan. Space the plan L M N O into a number of equal parts, as shown by the small figures. Before being able to obtain the patterns the miter line shown

in elevation by F G, forming the intersection between the shaft and cone, must first be established. To do so proceed as follows: From the spaces obtained on M L O in the plan view draw lines to the center point, U, as shown, intersecting one of the sides, P R, of the shaft. Now parallel to the axis A L of the cone draw lines from the intersection in the half plan, M L O, intersecting the base of the cone B C. From these points draw lines to the apex A, as shown. Now from the intersections on the side of the shaft P R in plan draw lines upward parallel to the axis of the cone, each intersecting the radial lines of corresponding numbers that have just been drawn. To obtain the point of intersection on the

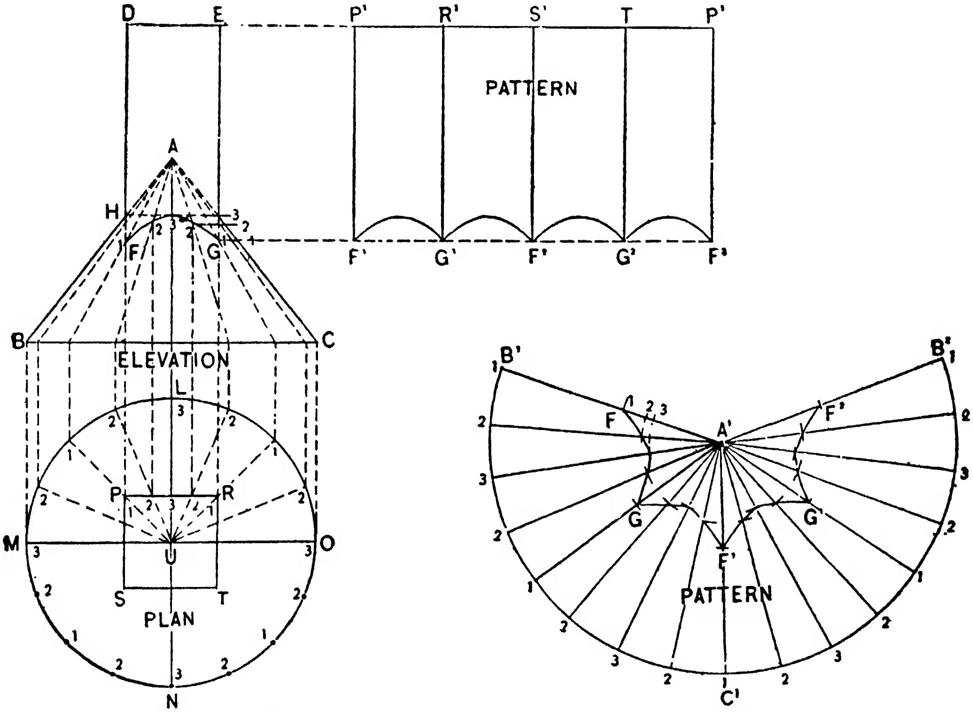


Fig. 19. Plan, Elevation and Pattern for Shaft

Fig. 20. Pattern for the Cone

center line 3 in elevation, proceed as follows: From where the line of the shaft D F intersects the side of the cone A B, as indicated at H, draw a line at right angles to D H, intersecting the center line 3, as shown at 3. Trace a line through these intersections, as shown. Then will F 2 3 2 G represent the miter line in elevation between the intersection of the shaft and the cone, and will at the same time give the pattern for one side of the shaft.

To obtain the pattern of the shaft in one piece, draw at right angles to the line E G of the shaft the stretchout line P^1 P^1, upon which place the stretchout of the square shaft shown in plan by P S T R, and as indicated on the stretchout line by P^1 R^1 S^1 T^1 P^1. At right angles to P^1 P^1 draw the usual measuring lines, as shown,

which intersect with line drawn at right angles to E G from G. Now trace the miter line F 2 3 2 G shown in elevation upon each side of the shaft, as shown in pattern by F^1 G^1 F^2 G^2 F^3. Then will P^1 F^1 F^3 P^1 be the required pattern for the square shaft mitering upon the cone.

At right angles to the axis of the cone draw lines from the intersections 3, 2 and G in the miter line, cutting the line A C of the cone, as indicated by 3 2 1. For the pattern of the cone proceed as follows: Set the compasses to the space A C, or the slant hight of the cone, and from any convenient point as center, as A^1 in Fig. 20, strike an arc indefinitely. Connect one end of the arc to the center point, as shown by the line B^1 A^1. From the point of the arc B^1 step off the divisions shown in the plan L M N O in Fig. 19, as indicated by the small figures shown in the pattern in Fig. 20, making them of corresponding numbers to those in the plan in Fig. 19, and draw radial lines to the center A^1 of the pattern in Fig. 20 in like manner, with the radii A 3, A 2 and A 1 of the elevation in Fig. 19, and with the A^1 of the pattern as center in Fig. 20, describe arcs indicated by 3, 2 and 1, intersecting radial lines of corresponding numbers as shown. Trace a line through these intersections, as shown by F, G, F^1, G^1 and F^2. Then will B^1 C^1 B^2 F^2 G^1 F^1 G F represent the desired pattern of the cone.

PATTERN FOR TAPERING PANEL

To cut the pattern for a tapering panel, a sketch of which is shown in Fig. 21, let A B C D be the plan of the panel and E F G a section on the line B D, the elevation being shown by H I J. The central lines in elevation, plan and section are indicated by the dotted line K M L. As each quarter plan is uniform it will will only be necessary to obtain the pattern for one quarter. The pattern will be developed by triangulation; therefore divide the quarter plan D C into equal spaces, as shown by the small figures 1 to 9, and draw lines as shown to the center of the plan M. These lines will represent the bases of the triangles, the altitudes of which are equal to K I in elevation or F L in section. Now measure each and every line, in plan from M 1 to M 9 and place the lengths as

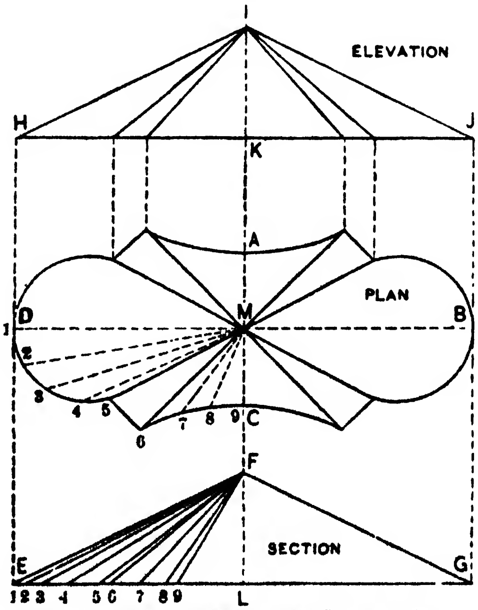


Fig. 21. Plan, Elevation and Triangles

shown in section from L 1 to L 9 measuring in each and every instance from the point L. From the small figures 1 to 9 draw lines to the apex F. Then will these lines F 1 to F 9, represent the true distances on the finished article on lines of similar numbers in plan.

For the pattern proceed as follows: With any point, as A in Fig. 22, as center and with radii equal to F 1 to F 9 in section in Fig. 21 describe arcs as shown in Fig, 22 by 1, 2, 3, 4, 5, 6, 7, 8 and 9. From any point on the arc 9 draw the line 9 A. Now set the dividers equal to the divisions in 9 6 in plan, Fig. 21, and setting one leg of the compasses in the point 9 of Fig. 22 step from one arc to the other of corresponding numbers until the point 6′ on the arc 6 has been obtained. Now take the distance 6 5 in plan, Fig. 21, and step from 6′ of Fig. 22 to the arc 5, as shown by 5′. Now set the dividers equal to the divisions in 5 1 in plan, Fig. 21, and starting from the point 5 on the arc 5 of Fig. 22 step from one arc to another having corresponding numbers until the point 1′ on the arc 1 is obtained. Draw a line from 1′ to A and trace a line through intersections on the various arcs, as shown from 1′ to 5′ to 6′ to 9. Then will A 9 1′ be one quarter of the pattern. If the pattern is desired in one piece trace the quarter pattern opposite the lines A 1′ and A 9, as shown. Then will 9′ 1′ 9 1″ 9″ be the full pattern.

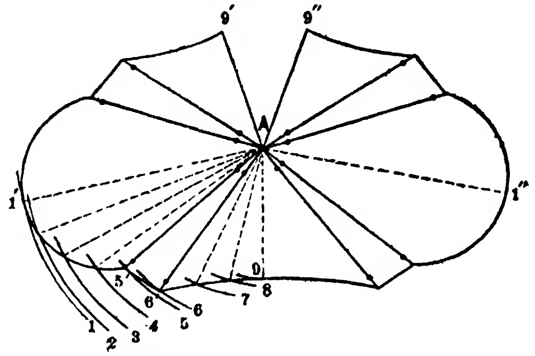


Fig 22. The Complete Pattern

A SHORT RULE FOR OBTAINING THE PATTERN OF A SUN PANEL OF ANY SHAPE

Let C D E F in Fig. 23 represent the front elevation of a square molded panel, into which the sun panel shown by Y J K L A M N O Z is to be placed. G Z H I in section represents the section through A B in front elevation, and Y Z H H^1 in section represents the section through A A^1 in elevation, and also gives the flare of the flute through A A^1 in front elevation. B Y^1 A^1 Z^1 in front elevation gives the outline of the half circle against which the bottom of the flutes miter. The rule to be observed in using this short method is that the lines of the sun panel shown by Y Y^1, J J^1, K K^1, L L^1, etc., all meet in one center point, as shown at B. After the lines of the flute have been drawn to the center point B draw the curves, as shown from Y to J, J to K, K to L, etc.

With B as center and B A as radius, strike an arc from A, cutting the line L L^1 at P. Now bisect the arc A P by the dotted line shown by X B. Draw a straight line from A to P, upon which place the section which the flute is to have at that point, as shown by A T^1 P. The hight of the section in the center, as shown by O T^1, corresponds to the projection of the flute Y Z in section. Divide the section V into an equal number of spaces, as shown by the small figures.

The same method is followed for obtaining the section for flute **3**. With B as center and B L as radius strike the arc L S R, cutting the line K K^1 at R. Bisect L R by the dotted line W B, as shown. Draw a line from L to R, upon which make O^2 S^1 equal to Y Z in section. Then draw the section L S^1 R, as shown by U, and divide into spaces as shown by the small figures. As the flute **4** is the same as **5**, **1** and **8**, and the flute **3** the same as **2**, **6** and **7**, it is only necessary to obtain the sections of these two flutes **3** and **4**, as shown.

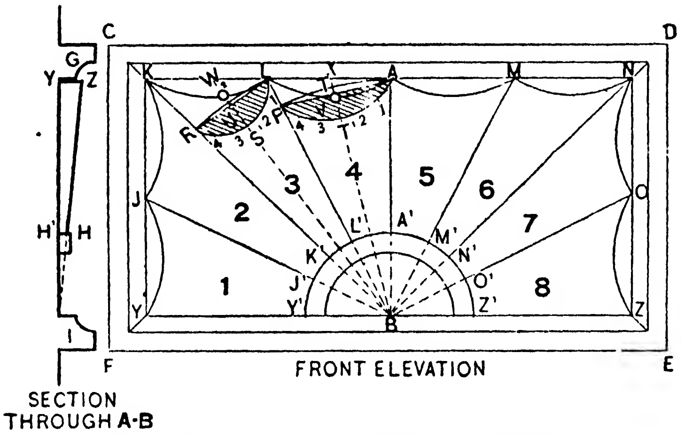


Fig. 23. Front Elevation and Section

To obtain the pattern proceed as follows: Draw any perpendicular line, as A^2 B^2 in Fig. 24, making it in length equal to A B in Fig. 23. Now with B^2 as center in the pattern and B^2 A^2 as radius strike the arc A^2 T^2 P^2, making it in length equal to the stretchout of the section V in Fig. 23, as shown by the small figures A^2, 1, 2, T^2, 3 4 and P^2 in Fig. 24. Draw a line from B^2 to P^2, extending it indefinitely, as shown. With B L in Fig. 23 as radius and with B^2 in Fig. 24 as center strike the arc L^2 S^2 R^2, as shown, cutting the line B^2 P^2 at L^2. Upon the arc L^2 S^2 R^2 place the stretchout of the section U, shown in Fig. 23, as shown by the small figures L^2, 1, 2, S^2, 3, 4, R^2 in Fig. 24. Draw a line from the center point B^2 to R^2, extending it indefinitely. Take the distance from R to K in Fig. 23 and place it on the line B^2 R^2 extended in Fig. 24, as shown from R^2 to K^2.

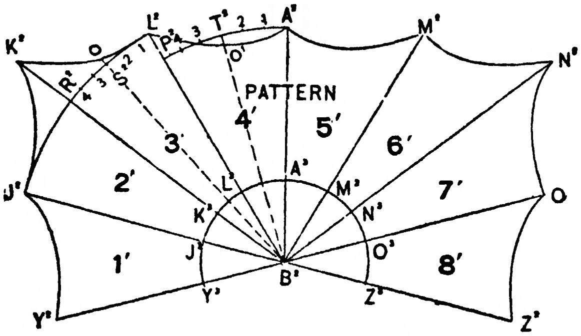


Fig. 24. The Pattern Shape

Bisect the two arcs A^2 T^2 P^2 and L^2 S^2 R^2 in pattern by dotted lines shown by S^2 B^2 and T^2 B^2 corresponding to the dotted lines X B and W B in Fig. 23. Now take the distance from the center point B in front elevation to where the outline L A of the flute **4** intersects the dotted line X B at O and place it in the pattern in Fig. 24, as shown from B^2 to O^1 on the dotted line T^2 B^2 in the flute **4**′. Trace a line, as shown by L^2 O^1 A^2. Now take the distance from the center point B in front elevation in Fig. 23 to where the outline K L of the flute **3** intersects the dotted line W B, as shown at O^2, and place it in the pattern in Fig. 24, as shown from B^2 to O on the dotted line S^2 B^2 in the flute **3**′. Trace a line, as shown by K^2 O L^2.

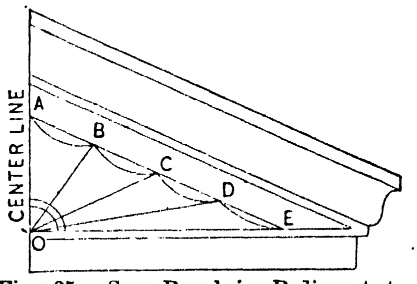


Fig. 25. Sun Panel in Pediment to Which the Principles Can be Applied

Now with B^2 of the pattern as center and B Y^1 in Fig. 23 as radius strike the arc Y^3 A^3 Z^3, as shown in Fig. 24. Then will K^2 K^3 L^3 L^2 be the pattern for flute **3** in the elevation in Fig. 23, and L^2 L^3 A^3 A^2 in Fig. 24 be the pattern for the flute **4** in the elevation in Fig. 23. If the pattern is desired in one piece, as shown in Fig. 24, the portion of pattern **4**′ **3**′ can be turned over on the line K^2 K^3, resulting in a duplicate, shown by **2**′ **1**′, having then the half of pattern. It can be turned over on the center line A^2 A^3 and traced, thus giving the other half, indicated by **5**′, **6**′, **7**′ and **8**′, the figures in the pattern representing similar figures in the elevation in Fig. 23.

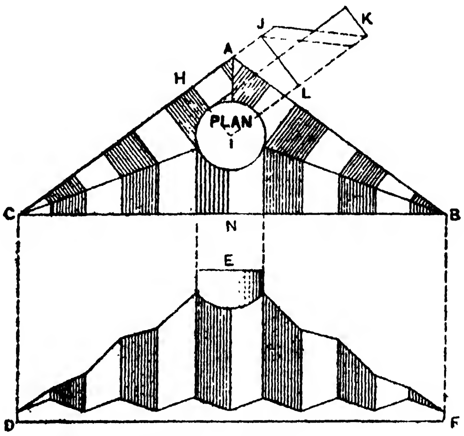
If the outline of the panel were the same as shown by A B C D E O in Fig. 25 the same method would be used. No matter what shape or outline the panel has the above rule holds good. Although not geometrically correct, it is accurate enough for all practical purposes. By referring to the front elevation in Fig. 23 it will be seen that the sections of the sun panel V and U are convex. The same method is employed if the sections are concave, it being only necessary to reverse the sun panel when soldering in position.

PATTERN FOR SUNBURST

To obtain the pattern for an article, which is called a triangular sunburst, and which is reproduced in Fig. 26, A B C being the plan view of the sunburst and D E F the elevation on the line B C in plan. It is required that the distance N I in plan be greater than I H, and that J K L represent the section on I H, showing the pitch of the flutes. The problem gives an interesting study in raking profiles and pattern drafting.

In Fig. 27 is shown an enlarged half plan, showing the sections and profiles and points of intersections on the pitched lines. Let A B C represent the one-half plan of sunburst and D E F the half plan of the cylinder, against which the flutes are to miter. Draw the true profile on A B in plan at pleasure, which will at once be the pattern for the closed end, as shown by H I J K.

Number each bend as shown from 1 to 8. From A in plan draw the miter line A G, intersecting the half circle D E F at E, G representing the center point from which the semicircle is struck. At right angles to A B and from the intersections 1 to 8 in the true profile draw lines, as shown, intersecting the miter line A E from 1 to 8. Draw a line from H to 3 in the true profile on A B and extend the line 2 2, intersecting the base line K J at *a* and H 3 at *b*, and call the point 2 *c*. Then will *a b c* represent the vertical hights of the flutes on the line A B in plan, which will be used in constructing a section on B G in plan, as follows:



FRONT ELEVATION
Fig. 26. The Sunburst

Draw any line, as L M, parallel to B G. At right angles to B G and from B and G draw the lines L R and M P indefinitely. Take the hights *a*, *b*, *c* in the true profile and place them, starting from M, as shown by *a′*, *b′*, *c′*, thus obtaining the points M, O, P, in section. Now establish at pleasure the point R on the line L R and draw a line from R to P, and from O draw a line parallel to R P, as shown by O N. At right angles to R P draw any line, as *ef*, which will represent the depth of the flutes at right angles to the rake. Then will N O P R be the true section on B G in plan, and N R R^2 X the section of the cylinder on G F in plan. It will now be necessary to obtain a true section on the line *e f* in section, as follows: Take the distance *ef* and place it on the line A K, extended, as shown, from *e′* to *f′*. Parallel to K J and from *e′* and *f′* draw the lines *e′ l* and *f′ m*. At right angles to K J and from points 2, 4, 6 and 8 in the true profile drop lines, intersecting the line *e′ l* at 2′, 4′, 6′ and 8′, and at right angles to K J and from points 1, 3, 5 and 7 drop lines, intersecting the line *f′ m* at 1′, 3′, 5′ and 7′. Now connect the points, as shown by the lines 1′ to 2′ to 3′ to 4′ to 5′ to 6′ to 7′ to 8′, which will represent the true profile on the line *e f* in section.

As the line R P in section represents the points shown in the profile having even numbers, as 2′, 4′, 6′, 8′, and the line N O in section represents the points shown in profile having uneven numebrs, as 1′, 3′, 5′ and 7′, then, at right angles

to G B in plan and from points 2, 4, 6 and 8 on the miter line in plan, erect lines, intersecting the line R P in section, as shown by points 2, 4, 6 and 8. In similar manner, at right angles to G B and from points 1, 3. 5 and 7 on the miter line in plan erect lines, intersecting the line N O in section at points 1, 3, 5 and 7. Now, at pleasure, between the arc E F in plan, establish the point 9, and parallel to F B drop a line, intersecting the true profiles at *i* and *d* and the line *f′ m* at *b″*. Take the distance from *b″* to *d* and place it at right angles to N O in section, as shown by K *d″*. From *d″*, parallel to N O, draw a short line, as shown by *d′ d″*, which inter-

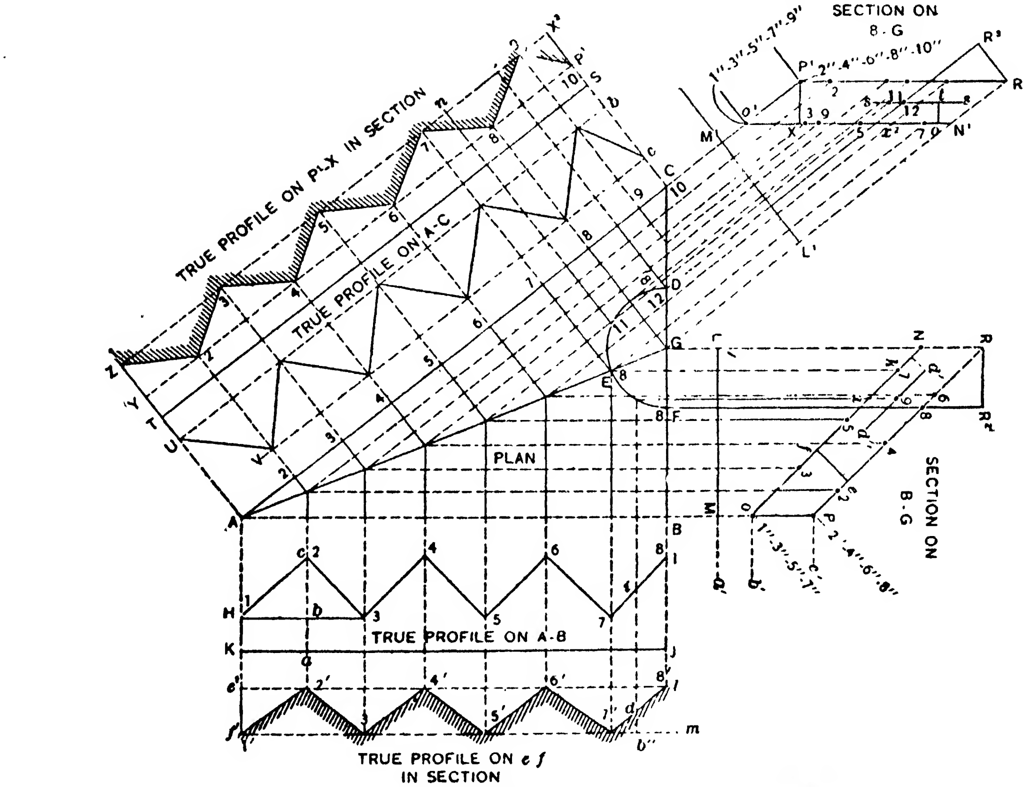


Fig. 27. Enlarged Half Plan, Sections and Profiles

sect by a line drawn from the point 9 in plan at right angles to G B, thus obtaining the point 9 on the line *d′ d″* in section. As P O in section represents the vertical cut through the flutes, then will P represent the even numbers in profile, as shown by 2″, 4″, 6″ and 8″, and O the uneven numbers, as 1″, 3″, 5″ and 7″. Having obtained the points of intersections on the section, the pattern is developed as shown in Fig. 28, in which R P O N, with the various points of intersection on same, is a reproduction of R P O N in section in Fig. 27 with the various intersections.

At right angles to R P in Fig. 28 draw the line J K, upon which place the stretchout of the true profile on *e f* in section in Fig. 27, as shown by the small

figures 1, 2, 3, 4, 5, 6, 7, 9, 8 on the line J K in Fig. 28. At right angles to J K and through these small figures draw lines indefinitely, as shown, which intersect with lines drawn at right angles to R P from intersections having similar numbers, as shown in R P O N. A line traced through points of intersections thus obtained, as shown by A B F E, will be the pattern for A B F E in plan in Fig. 27, formed after the profile f' l, while the true profile on A B will be the pattern for the vertical face of the flutes shown by P O in the section.

As the distance 8 G at right angles to A C in plan is less than G B, it will be necessary to construct a true section on 8 G in plan from which to obtain the true profiles necessary to form a miter with the opposite flutes on the line A E in plan. Therefore, parallel to 8 G draw the line M^1 L^1, and at right angles to 8 G and from points 8 and G erect the lines G R^1 and 8 P^1 indefinitely, as shown, intersecting the line M^1 L^1 at M^1 and L^1. Now take the hights from L to N to R in the section on B G and place them, as shown, from L^1 to N^1 R^1 in the section on 8 G. In similar manner take the hights from M to O to P in the section on B G and place them in the section on 8 G, as shown, from M^1 to O^1 to P^1. Now draw a line from R^1 to P^1 and from N^1 to O^1. Then will $N^1 O^1$ $P^1 R^1$ be the true section on 8 G in plan and $N^1 R^1 R^3 X^1$ the section of the cylinder on 8′ G in plan.

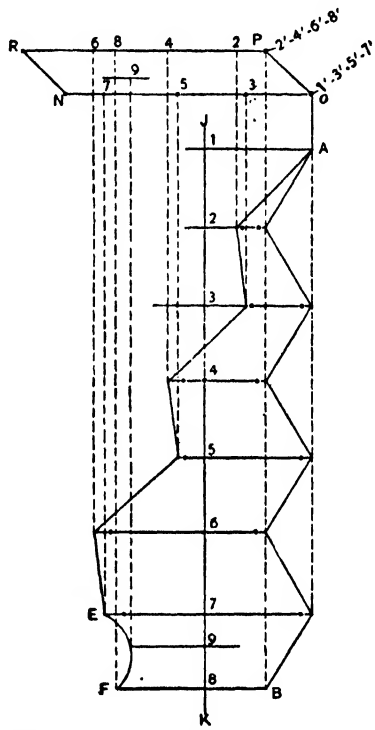


Fig. 28. Pattern for A E F B of the Plan, Fig. 26

From the point P^1, at right angles to P^1 R^1, draw the line P^1 X, which gives the depths of the flutes at right angles to the rake. At right angles to A C in plan and from the various intersections from 1 to 7 on the miter line draw lines, intersecting the line A C from 1 to 7. Set the dividers equal to one of these spaces and step off on A C, 7 to 8, 8 to 9, and let 9 to 10 be as it may. Then, at right angles to A C and from the intersections 1 to 10 on A C draw dotted lines indefinitely, as shown.

At pleasure draw any line, as S T, parallel to C A. Now take the hights from M^1 to O^1 to P^1 in the section and place them at right angles to S T, as shown by S *b c*. From *b* and *c*, parallel to S T, draw the lines *b* U and c V, letting *b* U, which represents the bottom line of the flutes, intersect the lines drawn from uneven numbers, as 1, 3, 5, 7 and 9, and the line *c* V intersect lines drawn from even numbers,

as shown by 2, 4, 6, 8 and 10. Trace a line through points thus obtained; then will T U V *c b* S be the true profile on the line A C in plan, shown in section by O^1 P^1, and will at once be the pattern for the vertical bottom or head to close the ends of the flutes on the line A C in plan.

For the true profile on P^1 X in section draw any line parallel to C A in plan, as X^2 Z. Take the distance from X to P^1 in the section and place it, as shown, from X^2 to P^1, at right angles to Z X^2. From P^1 draw a line parallel to X^2 Z, as shown by P^1 Y. As X^2 Z represents the bottom of the flutes, then must this line intersect uneven numbered lines, as 1, 3, 5, 7 and 9, and the line P^1 Y intersect even numbered lines, as 2, 4, 6, 8 and 10. Draw lines connecting these numbers, as shown by the shaded lines 1 to 10; then will Z P^1 be the true profile on P^1 X in section. As the line P^1 R^1 in section represents the points shown in the profile Z P^1 having even numbers, as 2, 4, 6, 8 and 10, and the line N^1 O^1 in section represents points shown in profile Z P^1 having uneven numbers, as 1, 3, 5, 7 and 9, then, at right angles to 8 G in plan and from points 2, 4, 6 and 8 on the miter line erect lines, intersecting the line R^1 P^1 in section, as shown by points 2, 4, 6 and 8. In similar manner, at right angles to 8 G in plan and from points 1, 3, 5, 7 and 9 on the miter line in plan erect lines, intersecting the line N^1 O^1 in section at points 1, 3, 5, 7 and 9. Now, at pleasure, on the arc E D establish any point, as 11, and call the point D 12. From the points 11 and 12 and parallel to 8 G draw lines, intersecting the true profile Z P^1 at 11 and 12 and the base line X^2 Z at *n* and *o*. Take the distance *n* 11 and *o* 12, which in this case are equal, and place them at right angles to N^1 O^1 in section, as shown by *o t*. Through *t*, parallel to N^1 O^1, draw a short line, as shown by S S, which intersect by lines drawn from points 11 and 12 in plan at right angles to 8 G, thus obtaining the points 11 and 12 on the line S S in the section. As P^1 O^1 in the section represents the vertical cut through the flutes, then will P^1 represent the even numbers in the profile, as shown by 2″ to 10″, and O^1 the uneven numbers, as 1″ to 9″.

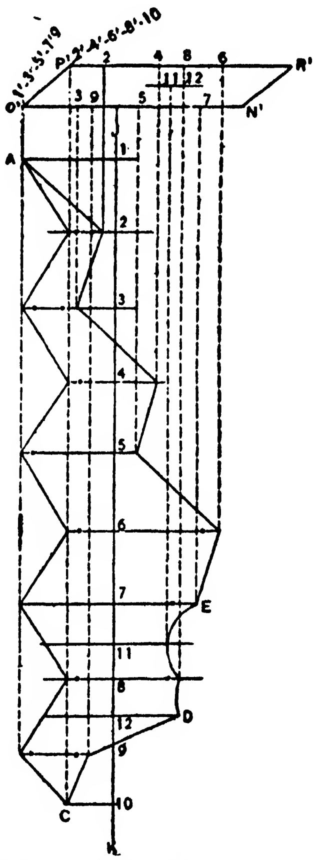


Fig. 29. Pattern for A C D E of the Plan Fig. 26

Having all the points of intersections on the section, the pattern is obtained as shown in Fig. 29, in which R^1 P^1 O^1 N^1, with the various points of intersection on

same, is a reproduction of R^1 P^1 O^1 N^1 in section in Fig. 27 having similar intersections. At right angles to R^1 P^1 in Fig. 29 draw the line J K, upon which place the stretchout of the true profile on P^1 X in section in Fig. 27, as shown by the small figures 1, 2, 3, 4, 5, 6, 7, 11, 8, 12, 9, 10 on the line J K in Fig. 29. At right angles to J K and through these small figures draw lines indefinitely, as shown, which intersect with lines drawn at right angles to R^1 P^1 from intersections having similar numbers in R^1 P^1 O^1 N^1. A line traced through points of intersections thus obtained, as shown by A C D E, will be the pattern for A C D E in plan in Fig. 27, formed after the profile Z P^1. It should be understood that the two patterns in Figs. 28 and 29 represent the half panel or sunburst, therefore there must be two of each pattern cut, one formed right and the other left. The pattern for the cylinder is not necessary, as that is made the same as a tube and slipped inside the circular opening of the sunburst.

PATTERNS FOR SUN PANELS

The triangular sections of pediments usually have some sort of ornamentation, and this article treats of the exact method of developing the patterns for a sun panel ornamentation; which can be either of a semi-circular section as at A Fig. 30, or triangular as at B.

As each flute in both sides of the pediment are different in length, a separate pattern must be obtained for each one, it will be explained how to obtain the pattern for the semi-circular flute **1** and the triangular flute **2**, the same principles being applied when developing the other flutes. In Fig. 31 let **A B C** represent a half elevation of the background of the pediment, in which the elevation of four flutes have been drawn, two semi-circular and two triangular, all radiating to the center **B**. Using **B** as a center, draw the quarter circle **D**. Draw a graceful sweep to the end of flute **1**, as shown by 1″, 3″, 5″; also draw the outline to the end of flute **2**, as shown by 6, 7, 8.

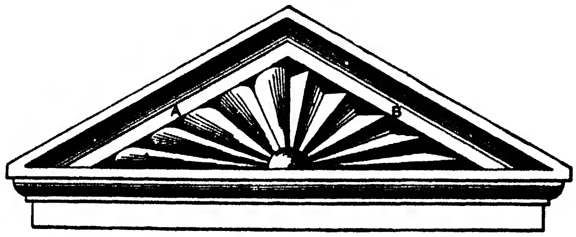


Fig. 30. Finished Ornamentations

Flute **1** will be developed first, the principles of which can be applied to any size semi-circular flute. Extend the sides of flute **1** indefinitely, as shown, and with any radius as **B** 5, using **B** as center, draw the arc *a* 1 intersecting the opposite side of the flute at 1. Draw a line from 1 to 5, which bisect, obtaining the point 3′. Now using 3′ as center and 3′, 5 as radius, describe the semi-circle 5, 3, 1,

which represents the profile of the flute on the line 1 5. Divide this semi-circle in equal spaces—in this case four—as shown from 1 to 5, and from these divisions at right angles to 1 5 draw lines intersecting the line 1 5 at $2'$, $3'$ and $4'$. From these points draw radial lines to the apex **B**, cutting the curve at the end of the flute at $1''$, $2''$, $3''$, $4''$ and $5''$, also cutting part of the quarter-circle **D** as shown. Now at right angles to the center line 3 **B** from the intersections $1''$ to $4''$ draw lines intersecting the side of the flute 5 B at 1^x to 4^x.

For the pattern proceed as follows: With **B** as center and **B** 5 as radius,

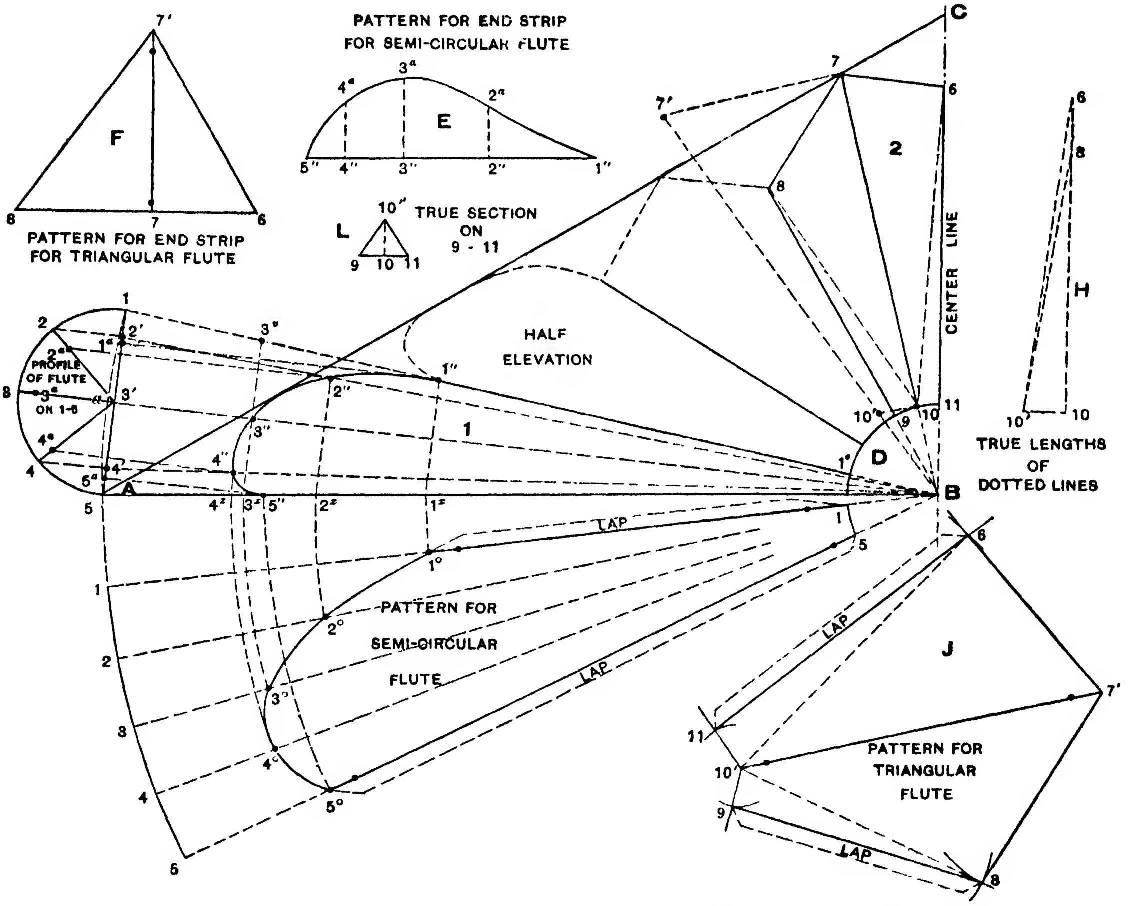


Fig. 81. Method of Obtaining Patterns for Semi-circular and Triangular Flutes

describe the arc 5 5, upon which place the girth of the profile on 1 5, as shown by the small figures 1 to 5 on the curve 5 5. From these small figures 1 to 5 draw radial lines to the center **B** and intersect them by arcs struck from **B** as center with radii equal to the various intersections 1^x, 2^x, 3^x, 4^x and $5''$ on the side of the flute 5 **B**, thus obtaining the intersections 1° to 5° in the pattern. In similar manner using **B** as center and **B**1° as radius, draw the arc 1 5 in the pattern. Then 1, 1°,

2°, 3°, 4°, 5°, 5, with laps allowed, will be the pattern for flute **1**. This flute can be used right and left.

Another pattern will be required for the end strip shown from 1″ to 5″, which closes the end of flute **1**, and is obtained as follows: From the various intersections 1 to 5 in the profile of flute, draw radial lines to the center 3′ as shown, and intersect these lines by lines dropped from similar numbered intersections 1″ to 5″ in flute **1**, parallel to the center line 3 **B**. Thus a line drawn from 1″ in elevation, intersects the radial line drawn from 1 in the profile at 1^a. A line drawn from 2″ in elevation intersects similar numbered radial lines in profile 2^a, while lines drawn from 4″ to 5″ in elevation intersect similar radial lines in profile at 4^a and 5^a, respectively.

To obtain the point 3^a in profile, a line is drawn from point 3″ in elevation, at right angles to 3 **B**, until it meets the side of the flute at 3^v or 3^x. Now take this distance, 3″ 3^v or 3″ 3^x and place it from 3′ to 3^a on the line 3′ 3 in the profile.

These points, 1^a to 5^a in the profile, will be used in obtaining the various hights for the end strip. Now take the girth of the various spaces along the curve 1″ to 5″ in elevation, measuring each one separately, as they are all unequal, and place them on any horizontal line in **E**, as shown by similar numbers 1″ to 5″. From these small figures erect perpendicular lines indefinitely as shown. Now measuring from the line 1 5 in the profile of flute, take the various hights to points 2^a, 3^a and 4^a and place them in the pattern **E** on similar numbered lines, measuring in each instance from the line 1″ 5″, resulting in the intersections 2^a, 3^a, 4^a. A line traced through points thus obtained as shown, will be the pattern for the end strip for the semi-circular flute **1**. In this manner must the balance of the end strips be obtained for the various flutes.

Let 6 7 8 9 10 11 be the outline of the triangular flute shown by **2**. The first step in developing this flute is to know the hight that the flute will have at 7. Assume that the hight at 7 should be as high as from 7 to 7′; then at right angles to 7 **B** draw the perpendicular 7 7 of the desired hight, and draw a line from 7′ to **B**, intersecting the line drawn from 10 at right angles to 7 10 at 10′. This hight 10 10′ then represents the hight of the flute on point 10. 7′, 10′, then shows the true length of the line 7 10; 8 9 and 6 11 also show their true lengths.

The true lengths must now be obtained on the dotted lines 8 10 and 10 6 as follows: Take the lengths of 8 10 and 6 10 and place them on any vertical line, as shown by similar numbers in diagram **H**. As the hight at 10 in elevation is equal to 10 10′, take this distance and place it as shown from 10 to 10′ in **H** at right angles to 6 10, and draw a line from 10′ to 8 and 10′ to 6, which show respectively

the true lengths of the dotted lines 10 8 and 10 6 in elevation. Now take the girth of the end 6 7 8 in flute **2**, and place it as shown by 6 7 8 in **F**. From point 7 erect the perpendicular 7 7′, equal to 7 7′ in elevation, and draw a line in **F** from 6 to 7′ to 8, which represents the pattern for the end strip for flute **2** and gives the true lengths for the end when developing the triangular flute **2**. In similar manner take the girth of 9 10 11 in flute **2**, and place it as shown by similar numbers in **L**; from 10 erect the perpendicular line 10 10′, equal to 10 10′ in flute **2**, and draw a line in **L** from 9 to 10′ to 11, which represents the developed section on 9 10 11 in elevation.

The pattern for flute **2** can now be developed as shown in diagram **J**. Draw any line 7′ 10′ equal in length to 7′ 10′ in elevation. Now with the radius equal to 6 7′ in **F**, and 7′ in **J** as center, draw an arc, which intersect by an arc struck from 10′ as center and 10′ 7 in **H** as radius. Now with 10′ 11 in **L** as radius and 10′ in **J** as center, draw the arc 11, which intersect by an arc struck from 6 as center and 6 11 in flute **2** as radius.

In similar manner complete the opposite side of the pattern **J**. 7′ 8 and 10′ 9 are obtained from 7′ 8 in **F** and 10′ 9 in **L** respectively, while the true lengths 10′ 8 and 9 8 in the pattern **J**, are obtained from 10′ 8 in **H** and 9 8 in flute **2** respectively. Connect intersections thus obtained in **J** by straight lines, to which allow laps as shown, which will then be the pattern for the triangular flute **2**.

It will be noticed that the lines 8 10′ 11 in pattern **J** are straight lines, but they intersect against a curved surface shown by 9 10 11 in the quarter-circle **D** in elevation, which, however, will hardly be noticeable in practical work.

Using the principles employed for developing the flute **2**, all other flutes having different lengths must be laid out the same way.

PATTERN FOR HORIZONTAL MOLDING INTERSECTING A TAPERING POST

This article exemplifies the method of obtaining the pattern for a horizontal molding intersecting a tapering post, as shown in Fig. 32. A and B represent the base and rail of a balustrade intersecting the tapering post C, *b* being the profile of the rail.

In Fig. 33 and 34 is shown the method of obtaining the pattern for the rail B in Fig. 32, which is also applicable to the base A. First, in Fig. 33 draw the center line A B and construct the part elevation of the post shown by C D E F.

In its proper position draw the section of the rail H. Divide this into any convenient number of spaces, being careful to place a few divisions in the vertical lines 1 11 and 8 10, as shown by 12, 13 and 9. Through these intersections draw horizontal lines through the elevation, as shown, which will represent the planes in elevation.

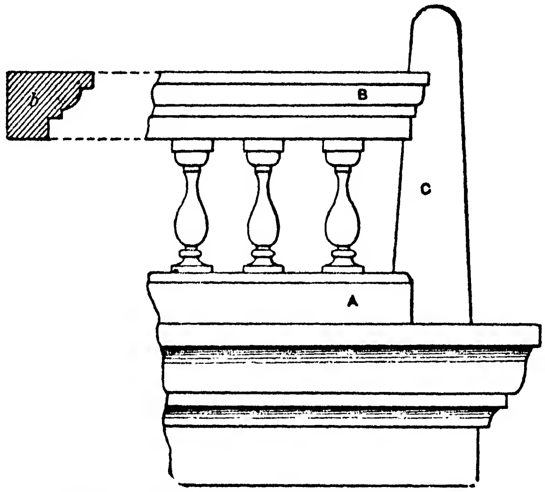


Fig. 32. Balustrade with Tapering Post

On the center line A′ B establish the point J, through which draw the line K L. From the various intersections of the horizontal planes with the line D E in elevation drop vertical lines intersecting the line K L in plan, as shown.

Using J as center, with the various radii describe circles, which will represent the various horizontal planes when viewed in plan. Take a tracing of section H in elevation and place it in its proper position in plan, as shown by H^1.

Through the various intersections in plan draw horizontal lines intersecting similar circles or planes, as shown from 1′ to 13′. If desired to show the miter line in elevation vertical lines can be erected from 1′ to 13′ in plan to similar lines in elevation, as shown from 1° to 13°, although this is not necessary in developing the pattern.

For the pattern shape for the horizontal molding take the girth of the section H or H^1 and place it on the line L M in Fig. 34, at right angles to which, from the various points, draw lines as shown. Erect at pleasure any vertical line, as L M in Fig. 33, from which take the various distances to points 1′ to 13′, and place them on similar lines in Fig. 34, measuring in each instance from the line L M and obtaining the intersections shown from 1″ to 1‴.

As the horizontal planes 1 2, 3 4, 7 8 and 10 11 in section H in Fig. 33 are represented by similar arcs of circles in plan, these arcs can be transferred to the pattern, as follows: With radius equal to J 1′ in plan, and 1″ and 2′, in Fig. 34 as centers, describe arcs intersecting each other at *a;* then using *a* as center describe the arc 1″ 2′. Using 3′ and 4′ as centers, and with radius equal to J 4′ in plan Fig. 33, describe arcs intersecting at *b* in Fig. 34; with *b* as center, using the same radius, describe the arc 3′ 4′.

Using radius J 7′ in plan in Fig. 33 and with 7′ and 8′ in Fig. 34 as centers describe the arcs *c;* with the same radius, and *c* as center, draw the arc 7′ 8′.

Using 10′ and 11′ as centers, and J 10′ in plan in Fig. 33 as radius, describe

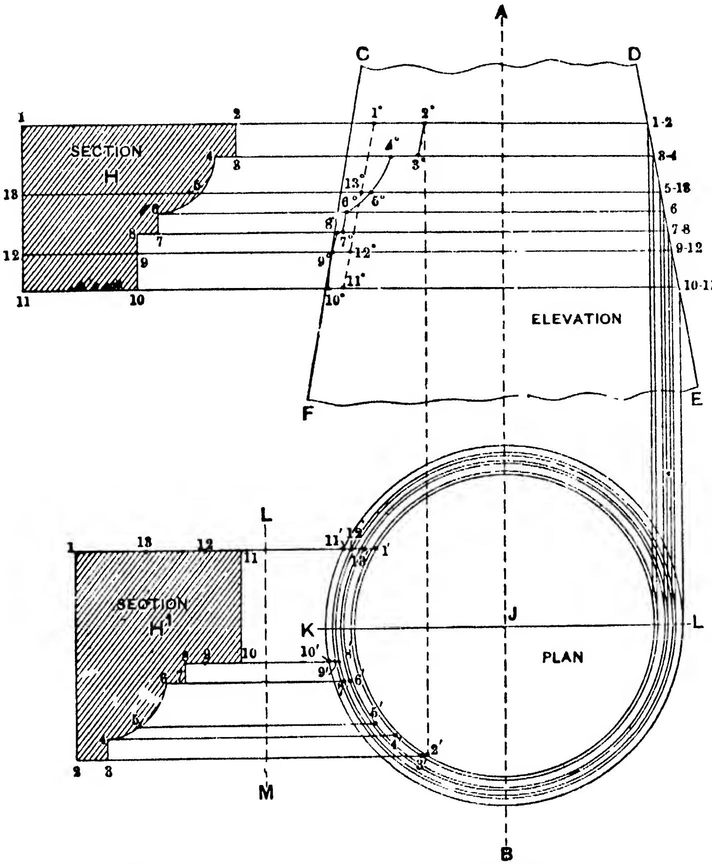


Fig. 33. Preparation for Developing Pattern

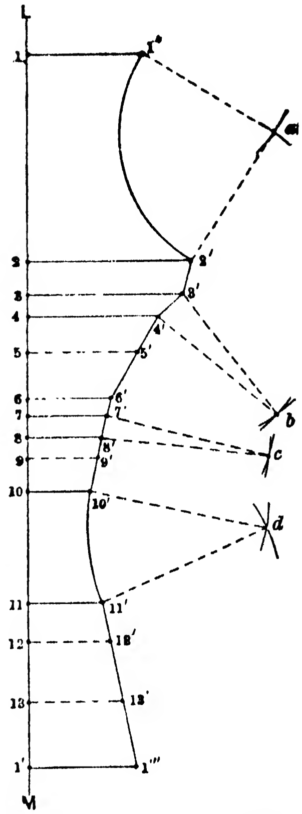


Fig 34. Pattern Developed

the arc 10′ 11′ in Fig. 34. Connect the various points as shown, which completes the pattern.

CORNICE RETURN CONFORMING TO ROOF PITCH

A vexing problem that frequently arises in the sheet metal cornice trade relates to making the crown return to the cornice conform to the pitch of the roof. In the majority of cases the roof pitches back from the cornice and the eminently practical method would be to make the return and crown mold of cornice level throughout. Then, after the cornice is set and wall is built up, the framer should lay the roof boards so that the roof will pitch back from the crown mold, or front of the building; and also at the return of cornice, he should build a saddle, creating a valley from the miter of the cornice to the inside line of the wall. It is then an easy matter to lay the roofing, all as indicated in Fig. 35.

It is a fact, though, that the framer often neglects to provide this saddle, and the roofer, finding that the crown return sticks up at the wall above the roof sheathing and caring little for the appearance of the cornice, squeezes the return out of shape until its flange lies on the roof boards throughout; for his only interest in the matter is to make the connection of his roofing with the cornice. Although it would be possible to guard against this by strict superintendence, occasions arise when, by reason of the design of the building and its structural formation in regard to the steel lookouts and the like, it is necessary to have the return pitch with the roof.

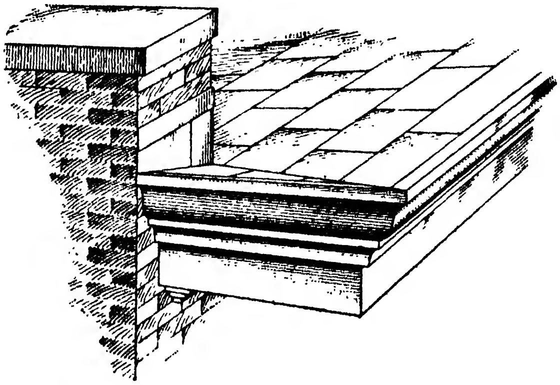


Fig. 35. Roof Pitch and Return of Cornice

In Fig. 36 is shown a method of pitching this return by allowing for a difference in hight of the return at the miter and at the wall line, in the facia members 5 4 J K. The problem is now similar to a raking pediment molding necessitating the ascertaining of the raked profile of the return. This is accomplished by dividing the profile of the crown molding as shown and placing its horizontal distance on any line as A B. This line, with the spaces numbered to correspond with those of the profile, is drawn parallel with the raking lines of the return, as A^1 B^1, and the lines dropped to the raking lines of the same numbers drawn from the profile of the crown O results in the modified profile P.

For the pattern, the stretchout of this profile P is placed on a line M N, which is at a right angle to the lines of the return; the usual parallel lines are drawn through the stretchout points on the line M N and are intersected by lines parallel to M N from the wall line K T and the profile O, which gives the pattern for the part of the return above the fascia member K J 4 5.

Add the fascia member to the pattern by scribing arcs from points 5′ and 5″ equal K J and 5 4 of the fascia. These arcs are intersected by lines drawn parallel to M N from points J and 4. A line joining these points of intersection on the arcs, as R S and from R to 5′ and S to 5″ is the pattern of the fascia member.

The pattern for the drip and planceer of the crown molding 4 to O is not raked and will be an ordinary square miter; hence, for the pattern of that part of the return, draw any line as X Y at right angles to line R S with the spaces 4 to 1 of the molding. Through these points on line X Y and parallel to R S draw lines. At

right angles to line A B draw any line as H G and at a distance equal to G 5 on line A B draw a line at right angles to R S indicated by H′ G′. From this line and on lines 3, 2 and 1, place the distance corresponding to G 1, etc., on A B.

A line traced through these points realizes the pattern for the drip of the return.

In most cases the planceer of the return is eliminated for the sake of appearance, obviating a conspicuous overhang for the return. In consequence the planceer of the crown molding from point 1 to 0 is a straight cut and on the return a lap is necessary as shown by the line R G′ in the pattern of the return. The pattern of the crown molding is simply a square return, with the exception of the above mentioned planceer part, and would be obtained by placing the stretchout of profile O on any lines (as H G continued) and dropping lines from points in profile O to similar numbered lines on H G extended. It should be understood that the rest of the cornice, the bed mold, frieze and foot mold, do not enter in this discussion.

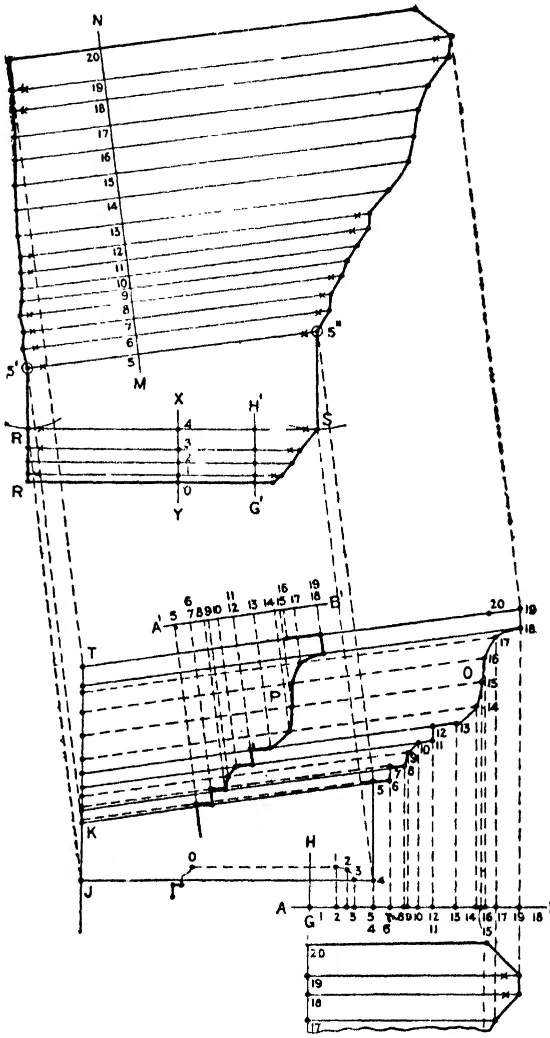


Fig. 36. Pattern for Return of Crown Molding

Should objections be raised to this manner of compensating in one member only and it is still essential to have the return conform to the pitch of the roof, each member of the return may bear the difference proportionally (in the hight of the crown return at the wall and outer edge as 19 of the profile O) by drawing the lines of all the members to a common center. This method was pursued in Fig. 37; and though it must be said that this scheme balances as it were, the evil, it

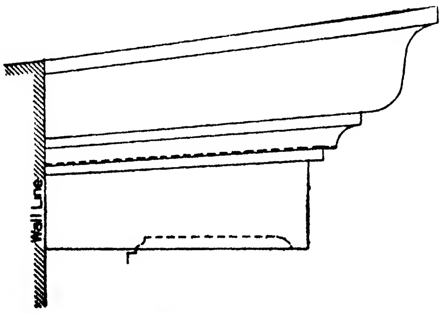


Fig. 37. One Way of Conforming to Roof Pitch

involves an intricate pattern, which apparently must be developed by the triangulation process. The question then comes to mind, would it pay when, as is often the case, the cornice is so high that the mode of compensating would be imperceptible to one on the ground?

PATTERNS FOR AN OCTAGONAL CORNUCOPIA

An exemplification of the methods of obtaining the patterns for an octagonal cornucopia, as shown in elevation and plan in Fig. 38. In working out the pattern in Fig. 39, the plan view will be omitted and the problem solved by a short method, the elevation, a sectional view, and a series of planes taken through the side elevation of the cornucopia only being used.

The first step is to draw a correct side view of the cornucopia, as indicated by 1 11 34 44 and then add the profile of the ornamental finish at the top from 1 to 4° and 44 to 4°. Directly above the side elevation draw the half plan of the ornamental finish, as shown by E^1 F^1 G^1 H^1 J^1, which equal one-half of a true octagon. In a similar manner below the line 11 34 in the side elevation draw the plan of the true opening shown by E. Take a tracing of the half section E and place it on the center line A° B° in the half plan, as shown by the smallest semioctagon. The from the corners of the largest semioctagon draw lines to the center C.

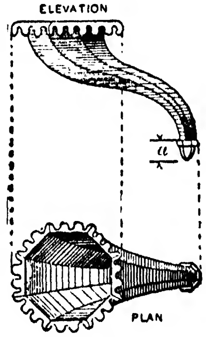


Fig. 38. The Octagonal Cornucopia

The next step is to draw a sectional view through the center of the cornucopia when viewed from the front, and this is done as follows: Extend the upper and lower lines of the cornucopia, as shown by 44 *a* and 34 *k*, at right angles to which draw the vertical line A B. As the top and bottom of the cornucopia are true octagons the widths through the front view will be similar to the widths in the side elevation. Therefore, measuring from the point C in the half plan, take the distance from C to *k* and C to *a*, and place them, measuring from the center line A B, from B to *k* and *k*°, and from A to *a* and *a*°, respectively, and then draw graceful curves from *a* to *k* and *a*° to *k*°. In practice it is necessary to draw only one-half sectional view. Next establish a series of planes through the side elevation by dividing the outline 1 to 11 into any desired number of spaces, and in a similar manner divide the outline from 34 to 44 into the same number of spaces. Connect opposite points as from 2 to 43, 3 to 42, 4 to 41, etc., down to 10 to 35.

On these planes true sections must be found, as shown in the half plan, which are obtained as follows: Bisect each plane in the side elevation as by the points *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, *i*, *j* and *k*, from which horizontal lines are drawn through the sectional view cutting the curve *a k*, as shown by similar letters. For example, to obtain the true section on the line 5 40 in the side elevation take the distances from *e*, which is the bisecting point of 5 40, to 5 and 40, and place it on the line A° B° in the half plan, as shown from C to 5′ and C to 40′. From 5′ and 40′ at right angles to A° B°, erect lines cutting the miter lines at 5 and 40 respectively. Measuring from the center line A B in the sectional view, take the distance to joint *e*, which represents the half depth through *e* in the side elevation, and place it as shown from C to *e*, on the center line, erected from C in the half plan, and through *e* parallel to A° B° draw a line intersecting the miter line at 18 and 27. Draw lines from 18 to 5 and 27 to 40. Then will 5′ 5 18 27 40 40′ be the true half section on the plane 5 40 in side elevation. In this manner are all of the semisections obtained on the various planes in the side elevation, as shown by similar numbers in the half plan.

All of the true sections having been obtained, the miter lines 12 22 and 23 33 in the side elevation must be found as follows: Measuring from the center line erected from C in the half plan take the distance from *a* to 22 and *a* to 23 and place it in the side elevation, measuring from the point *a* and obtain points 22 and 23. In a similar manner measuring from *b* in the half plan take the distances to points 21 and 24 and place them in the side elevation from *b* to 21 and *b* 24. In this manner all of the points from 21 to 12 and 24 to 33 are obtained, after which a line is traced through points thus found as shown from 12 to 22 and 23 to 33, which represents the miter line or line of joint. Connect opposite points by means of dotted lines as shown from 2 to 22 to 24 to 42, etc. The semisections in the half plan show the true lengths of similar numbered solid lines in the side elevation, but the true lengths of the dotted lines in the side elevation must first be found. For example, there will be shown how to obtain the true length of the dotted line 27 39 in the side elevations, and when this is understood the balance of the dotted lines can be easily obtained. Take the length of 27 39 in F in the side elevation, and place it in diagram K on the line A^{v} B^{v} from 27′ to 39′. At right angles to A^{v} B^{v} from points 27′ and 39′ erect lines, making 27′ 27 and 39′ 39 equal respectively to the vertical distances obtained in the half plan, measuring from the line A° B° to points 27 and 39. A line drawn from 27 to 39 in diagram K will be the true length of the line 27 39 in the side elevation. In this manner all of the true lengths on dotted lines in F in elevation are obtained, as shown in diagram K. The true lengths of the dotted lines in G and H, are obtained in a similar manner, as shown in diagram N, the various sections being erected from the line A^{D} B^{D}.

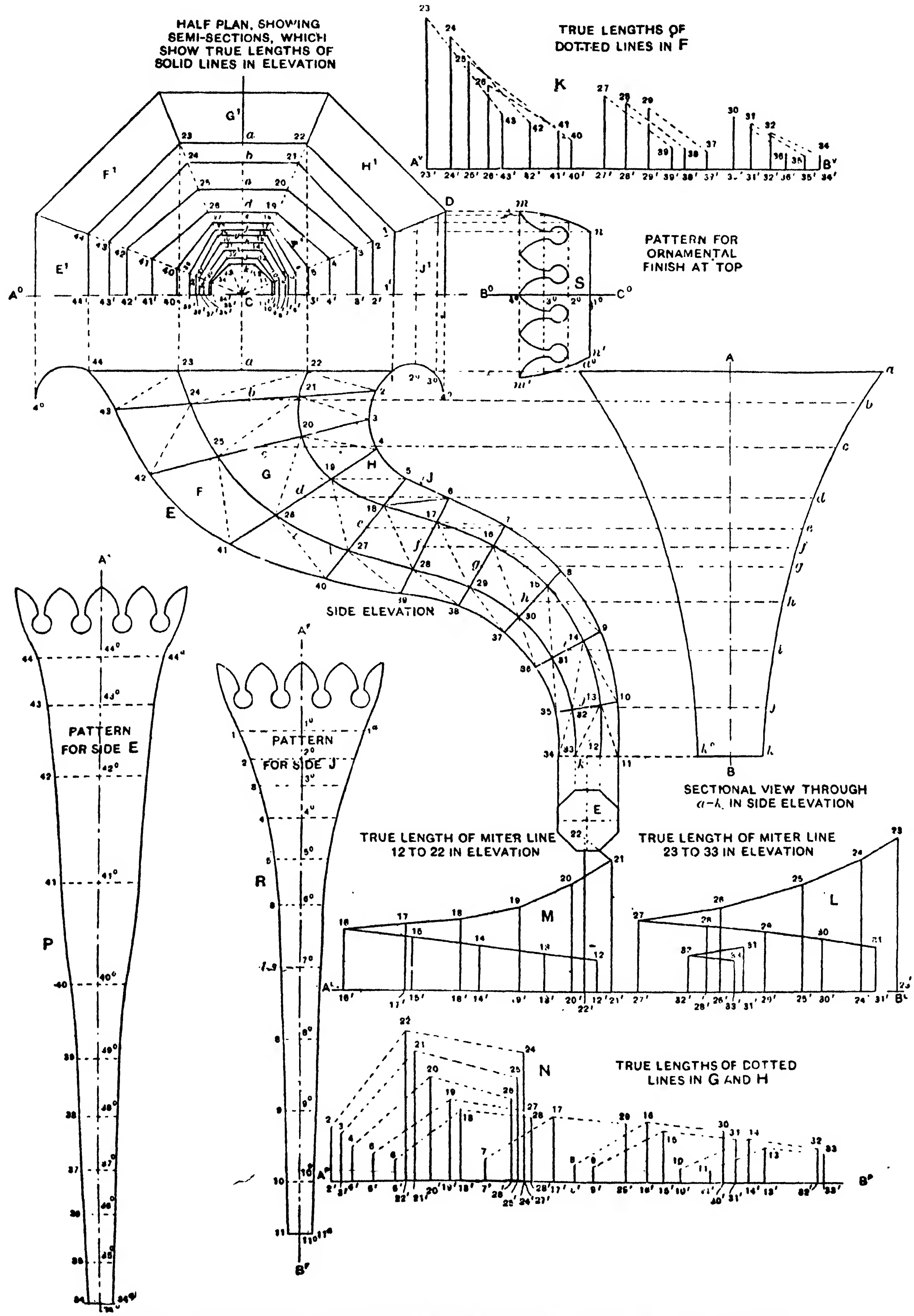


Fig. 39. Side Elevation, True Sections, True Lengths and Patterns for Parallel Sides

When the pattern for the lower piece of the cornucopia E in the side elevation is developed, as shown by P, the miter cut from 34 to 44 will give the true edge line for the lower part of the piece F in the side elevation. In a similar manner, when the upper part J in the side elevation is developed as shown by R, the miter cut from 1 to 11 will give the true edge line for the upper part of the piece H in the side elevation. It now becomes necessary to find the true lengths on the miter lines 12 22 and 23 33 in the side elevation as follows: Take the distances from 12 to 13, 13 to 14, 14 to 15 to 16 to 17 to 18 to 19 to 20 to 21 to 22 and place on the line A^1 B^1 in diagram M, as shown by similar numbers 12′ to 13′, to 14′ to 15′, etc., placing one over another so as to save space. At right angles to A^1 B^1 from the various small figures vertical lines are erected, equal to the various vertical hights of similar numbered points in the semisections in the half plan. For example, the hights, 12′ 12, 13′ 13, 14′ 14 in diagram M, are equal to the vertical distances, measured from the line A° B° in the half plan to points 12, 13 and 14. Lines drawn from points 12 to 13 to 14 in M give the true length of part of the miter line 12, 13 and 14 in the side elevation. The true length of the miter line from 23 to 33 in the side elevation, is obtained in a similar manner as shown in diagram L by similar numbers.

The necessary true lengths having been obtained, the patterns are now in order. The first pattern to be developed is that of the ornamental finish at the top. Divide the profile of the finish from 1 to 4° in the side elevation into equal spaces, and erect perpendicular lines until they cut the miter line 1 D. Extend the center line A° B° as B° C°, upon which place the girth of 1 4° in the side elevation, from 1° to 4° on the line B° C°. At right angles to 1° 4° through the small figures draw perpendicular lines and intersect them by lines drawn parallel to B° C° from similar intersections on the miter line 1 D. A line traced through points thus obtained will be the miter cut for an octagon bevel. Reverse this cut *m n* opposite the center line B° C° and obtain *m′ n′*. Then *m m′ n′ n* will be the pattern for the upper finish, which will be added to all patterns. At pleasure between the points *m* and *m′* draw any ornamental design such as the one shown.

For the pattern for the top J in the side elevation, take the girth from 1 to 11 and place it as shown by similar numbers 1° to 11° on any vertical line A^f B^f, at right angles to which through the small figures draw lines indefinitely. Measuring from the center line A° B° in the half plan, take the various distances to points 1 to 11 on the miter line C D and place them on similar numbered line in the pattern for the side J, measuring in each instance from and on either side of the line A^f B^f. Trace a line through points thus obtained. Then will 1 11 11^a 1^a be the pattern

for the upper side J in the side elevation or J^1 in the half plan. Take a tracing of the ornamental finish S and place it to the pattern R as shown. In a similar manner obtain the pattern for the lower side E in the side elevation. Take the girth of all the spaces between 34 and 44, and place them on any vertical line $A^x B^x$ as shown by similar numbers from 34° to 44°, through which points at right angles to $A^x B^x$, draw lines indefinitely. Measuring from the line A° B° in the half plan, take the various distances to similar numbers 34 to 44 on the miter line, and place them on either side of $A^x B^x$ on similar numbered lines as shown. A line traced

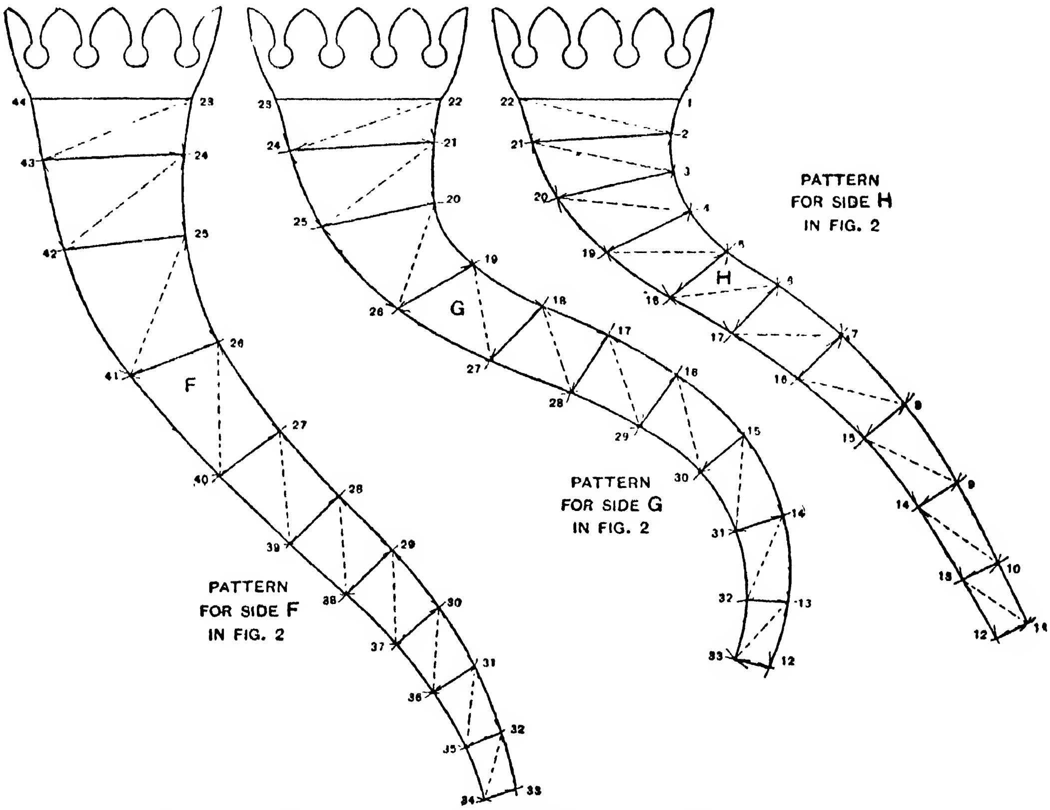


Fig. 40. Pattern Shapes for Three Sides of an Octagonal Cornucopia

through points thus obtained as shown by 34, 44, 44ª, 34ª will be the desired pattern, to which the ornamental finish is added.

As before mentioned, the miter cuts on both patterns P and R are used in developing, by triangulation, the patterns for the sides F and H, respectively, in the side elevation. The patterns for the three sides shown by F, G and H in the side elevation, or F^1, G^1 and H^1 in the half plan, are shown in Fig. 40. The method of developing the pattern F will be explained, then the same method can be applied to the patterns G and H. In developing the pattern for side F in side

elevation in Fig. 39 it should be remembered that the true lengths of the solid lines in elevation are given in the half plan; the true lengths of the dotted lines in F are shown in the diagram K; the true length of the miter line 23 33 in the side elevation is shown in diagram L, and the true edge line along 34 44 in the side elevation is found along the miter cut 34 44 in the pattern P. Proceed with the pattern for side F as follows: Take the distance of 23 44 in the half plan and place it as shown by 23 44 in F in Fig. 40. With a radius equal to the distance 44 43 in the miter cut in the pattern P and 44 in the pattern F in Fig. 40 as center, describe the arc 43, which intersect by another arc struck from 23 as center and 23 43 in diagram K in Fig. 39 as radius. Then with 23 24 in diagram L as radius and 23 in F in Fig 40 as center, describe the arc 24, which intersect by an arc struck from 43 as center and 43 24 in the half plan in Fig 39 as radius. Proceed in this manner, using alternately first the proper division on the miter cut in pattern P, then the proper numbered slant line in diagram K, the proper numbered slant line in diagram L, then the proper numbered line in the half plan, until the line 33 34 in F in Fig. 40 has been obtained. A line traced through points thus obtained, with the ornamental finish added, will be the pattern for the side F in Fig. 39.

In obtaining the pattern G in Fig 40, the divisions from 23 to 33 are obtained from the miter cut 23 to 33 in pattern F. The length of the solid lines in pattern G are obtained from the half plan in Fig 39, and the lengths of the dotted lines for pattern G in Fig. 40 are obtained from diagram N in Fig. 39; the outer edge line from 12 to 22 in the pattern G in Fig. 40 is obtained from diagram M in Fig. 39. When developing the pattern H in Fig. 40, the edge line from 12 to 22 is obtained from 12 to 22 in pattern G, while the true lengths of the solid and dotted lines in pattern H are obtained from diagram N in Fig. 39 for the dotted lines and from the half plan for the solid lines. The edge line from 1 to 11 in the pattern H in Fig. 40 is obtained from the miter cut from 1 to 11 in R in Fig 39. Edges must be allowed on all patterns for soldering purpose.

The small octagonal acorn shown at the bottom of the cornucopia at *a* in Fig. 38 is developed the same as an ordinary octagon miter.

PATTERN FOR MULLION INTERSECTING GABLE MOLD

An interesting problem in projection and development is given in the accompanying illustration, that of a mullion intersecting a gable mold. In Fig. 41 let A B C represent the angle of the gable mold, D being the profile at right angles to the rake. In its proper position place the profile of the mullion mold E, the lower

part of the mold from 2 to 8 being similar to similar numbers in the profile of the gable mold D. The wash or water table from 2 to 8° in E can be drawn at any

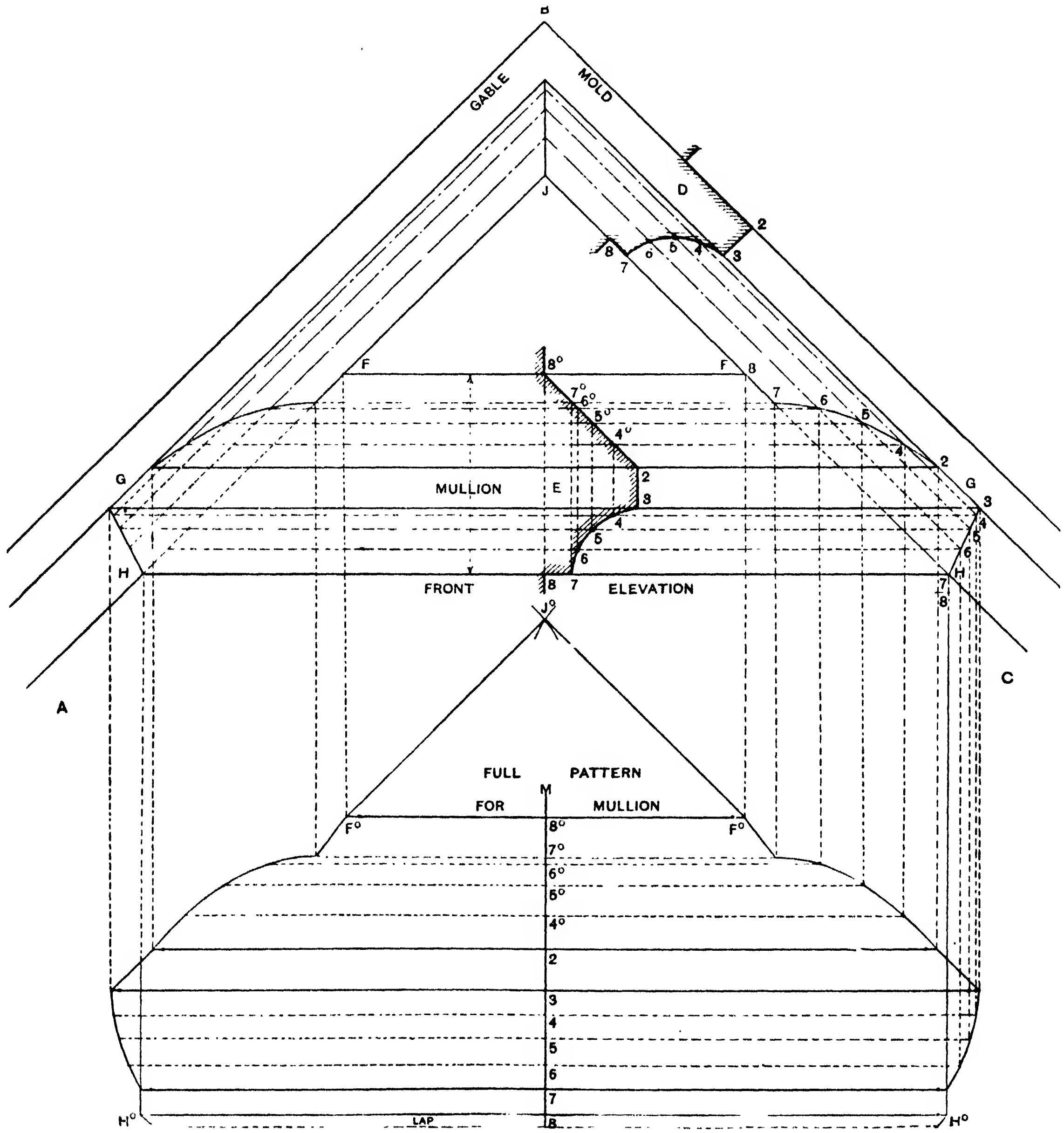


Fig. 41. Elevation, Profile, Miter Lines and Patterns

angle, being careful, however, that the point 8° is vertically above the point 8 as shown.

Divide the profiles D and E into similar number of parts as shown from 2 to 8. Through the points in the profile D, draw lines parallel to the gable mold indefinite-

ly as shown. Through the points in the profile E erect vertical lines from 4 to 8 until they intersect the wash from 4° to 8°. Then from the various intersections in the profile E draw horizontal lines until they intersect the lines drawn from the profile D in the gable mold, thus obtaining the points of intersections from 8 to 2 to 3 to 8, the miter line being shown traced by F G H. While both miter lines are here shown, it is only necessary to draw one-half in practice.

Having obtained the miter line, the pattern for the mullion is obtained as follows: Extend the center line of the gable as M L, upon which place the girth of the profile E from 8° to 2 to 8, being careful to measure each space separately, as they are all unequal as shown by similar numbers on M L. Through these points at right angles to M L draw lines, which intersect by lines drawn from similar numbers on the miter line F G H at right angles to H H. Trace a line through points thus obtained, then will H° F° F° H° be the full pattern for the mullion.

If it is desired to add the triangular face to the pattern shown by F J F in elevation, then use as radius the distance F J, and with F° and F° in the pattern as centers, describe arcs intersecting each other at J°. Draw lines from F° to J° to F°, which completes the pattern.

INTERSECTION OF HORIZONTAL WITH INCLINED DISSIMILAR MOLDING

This is the solution of the above problem which in Fig. 42 is represented the elevation of the moldings and indicating the inclined or gable molding by A B C D E F and the horizontal molding by G H J K. The profile of the gable molding is shown at X, and of the horizontal molding at Z. The pattern required is for the miter at G J or H K. In Fig. 43, part of the elevation in Fig. 42 is shown and enlarged. In this figure A B F E represents the inclined molding, the profile of which is shown at X. G H K J represents the horizontal molding and Z is the profile. To obtain the pattern G H J K where joints A B F E at G J, it is only necessary to acquire the miter line G J, when the pattern can be described in the usual manner.

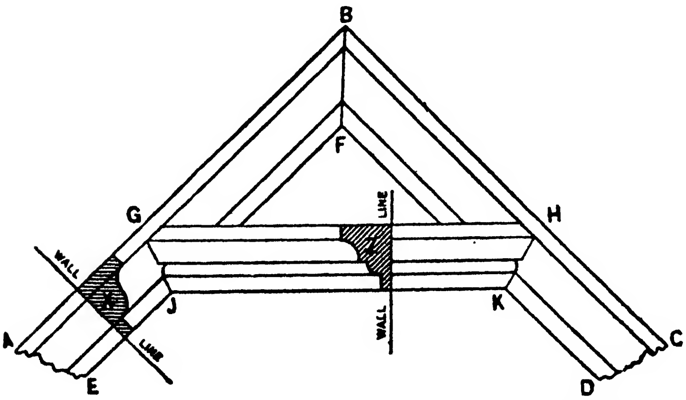


Fig. 42. Elevation of Inclined and Horizontal Moldings

In Fig. 43, 2 to 5 of the profile X miters with 2 to 5 of profile Z, and these two shapes are alike. From 5 to 9 of profile X miters with 5 to 9 of profile Z, and these two shapes are different. To obtain the miter line G J, proceed as follows: On the

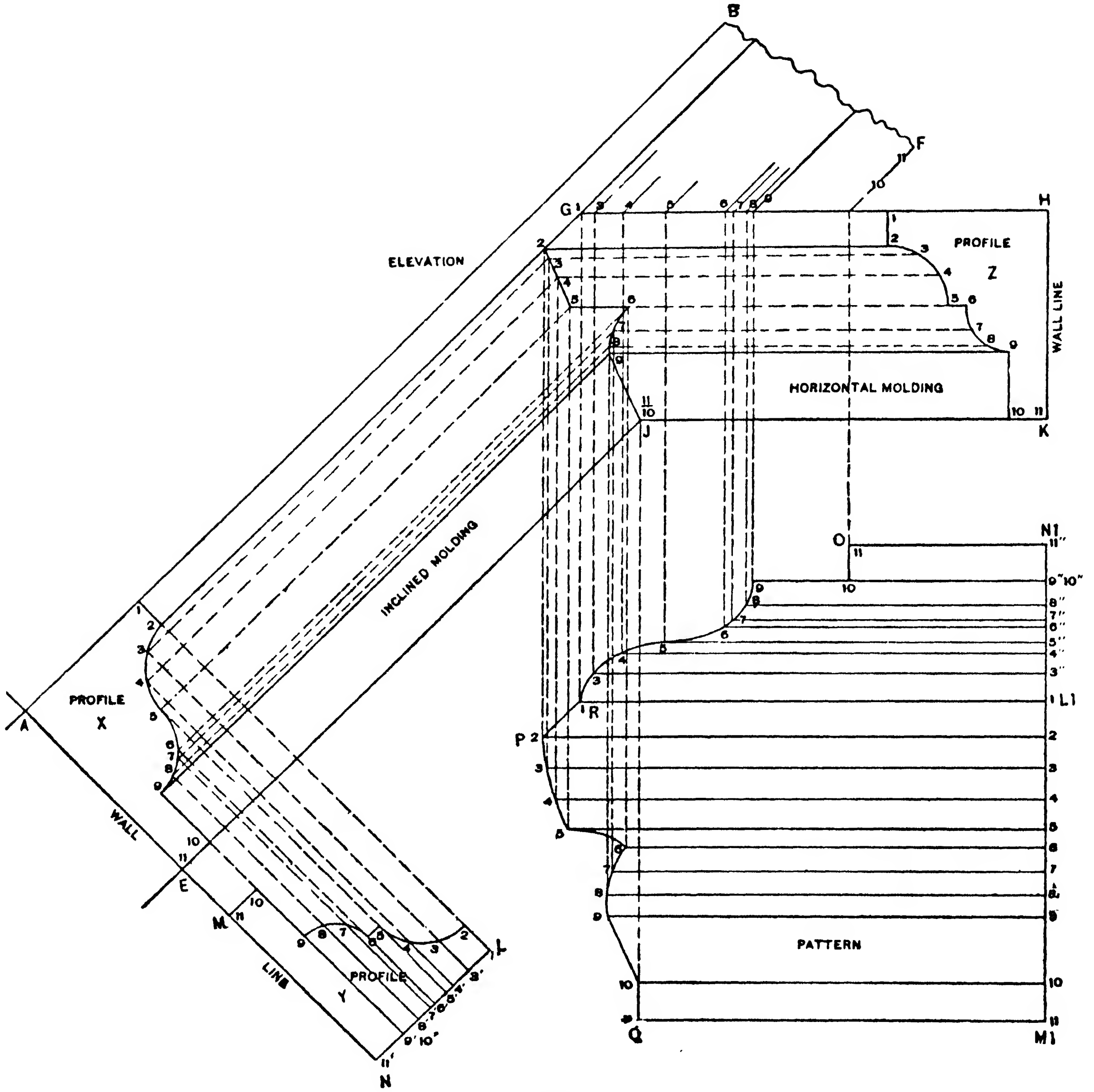


Fig. 43. The Intersection and Pattern

wall line A E extended, as M N, draw a duplicate of profile Z as shown. Divide the profiles Y and Z into the same number of parts, as indicated by small figures in each. From the divisions in profile Y carry lines parallel with the wall line A N, cutting the face of the profile X, and also carry the lines through profile Y, cutting L N, as shown by the small figures 1′ to 11′. With the T-square parallel with the lines of the inclined molding, as A B, carry lines from the points in profile X, extending them in the direction of B F. Also draw lines from the points in profile Z, cutting lines of similar numbers drawn from profile X. A line traced through these points of intersection, as shown by G J, will be the miter line.

For the pattern of the horizontal molding proceed as follows: At right angles to the horizontal molding, as on H K extended lay off a stretchout of N L M of profile Y, as shown by the points in N 1 M 1, in which N 1 to L 1 are the points in N L of the profile. Thus the distance L 1 3″ of stretchout is equal to L 3′ of profile. L 1 of 4″ of stretchout is equal to L 4′ of profile, etc. With the T-square at right angles to the stretchout line N 1 M 1 draw the measuring lines, in this case extending them to the left indefinitely. With the T-square parallel with the stretchout line M 1 N 1, drop lines from the points in G H of horizontal molding to lines of similar numbers drawn at right angles to N 1 L 1. A line traced through these points of intersections, as shown from O to R of pattern, will give the shape of pattern for the top of molding.

In a similar manner drop lines from the points in G J to lines of corresponding number drawn at right angles to L 1 M 1, when a line drawn through the points of intersection, as shown by R P Q, will form the remaining part of pattern.

PATTERN FOR A BROKEN SHAFT

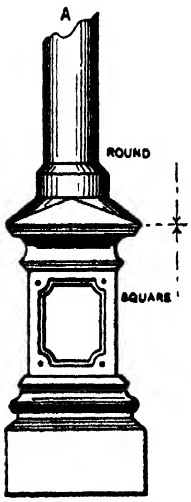


Fig. 44. View of

The following will describe how to cut the pattern for a monument of sheet metal representing a broken shaft, a sketch of which is presented in Fig. 44, A being the shaft resting upon a square base. In Fig. 45 let A B C D be the elevation of the broken shaft and E the plan. Divide the half plan into equal parts, as shown on the small figures 1 to 7. Through these divisions and parallel to the shaft A D drop lines until they intersect the center line in plan and erect perpendiculars intersecting the break A B, as shown by the small figures on A B.

For the pattern proceed as follows: In the line with D C draw line, as F H, upon which place the stretchout of the plan E, as

shown by the small figures 1 to 1. At right angles to F H and from the small figures erect perpendiculars, which intersect with lines of corresponding number drawn from A B of the elevation. Trace a line through the points thus obtained, as K J and F H J K will be the pattern for the broken shaft.

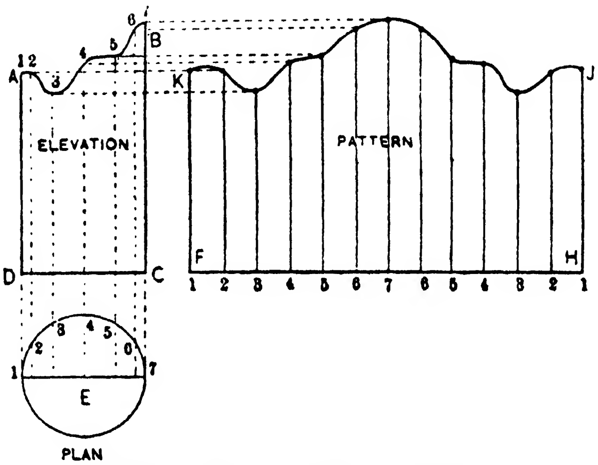


Fig. 45. Plan, Elevation and Pattern

For the pattern for the cover to close the broken part of shaft draw any line, as A B in Fig. 46, upon which place the stretchout of the break A B in Fig. 45. When taking the stretchout of the curve in A B in Fig. 45, and of the space from 3 to 4, it will be seen that the latter does not run in a straight line but is more or less curved; therefore make two divisions of this space and transfer them to 3 to 4 on A B of Fig. 46, as shown, the subdivision not being indicated on the stretchout line. Through these small figures and at right angles to A B draw vertical lines, as shown. Now, measuring in each instance from the line 1 to 7 in the plan E of Fig. 45, take the various distances to the small figures 2, 3, 4, 5 and 6 on the semicircle and place these distances on lines of similar numbers in Fig. 46, measuring in each instance above and below the line A B. Trace a line through the points thus obtained and C D will be the desired pattern.

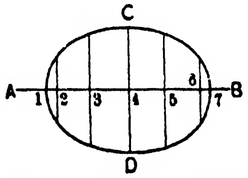


Fig. 46. Pattern of Head

PATTERN FOR HALF ROUND BRACKET STAND

To draw a pattern for the half round stand which is to be made in six pieces and to be set at an angle, as indicated by A B C in Fig. 47, proceed as follows: As the article is to be made in six pieces, placed in a half circle, draw any horizontal line, as D O^1, as the center line of the plan. Drop lines from the extreme points of the profile, as X and B, intersecting the horizontal line at D and O^1. Now with O^1 as center and O^1 D as radius draw a quarter circle (shown dotted) intersecting a line dropped from O^1 at P^1. Divide the quarter circle, P^1 D into three equal parts, as shown by H and G. Draw the lines D H, H G and G P^1 forming the sides of the bracket in plan. At right angles to A B in profile and from the point C drop a line, intersecting D O^1 at E. Then will E be the point to which all miter lines in plan will be drawn. Thus from the point E draw lines to H and

G. As the side of the stand shown in plan by G P^1 butts against a plain surface oblique in elevation, the miter line shown by F X E in plan must first be found from which to obtain the pattern.

To do this proceed as follows: It should be understood that the profile shown by A B C is a profile on the miter line D E in plan and is not a profile at right

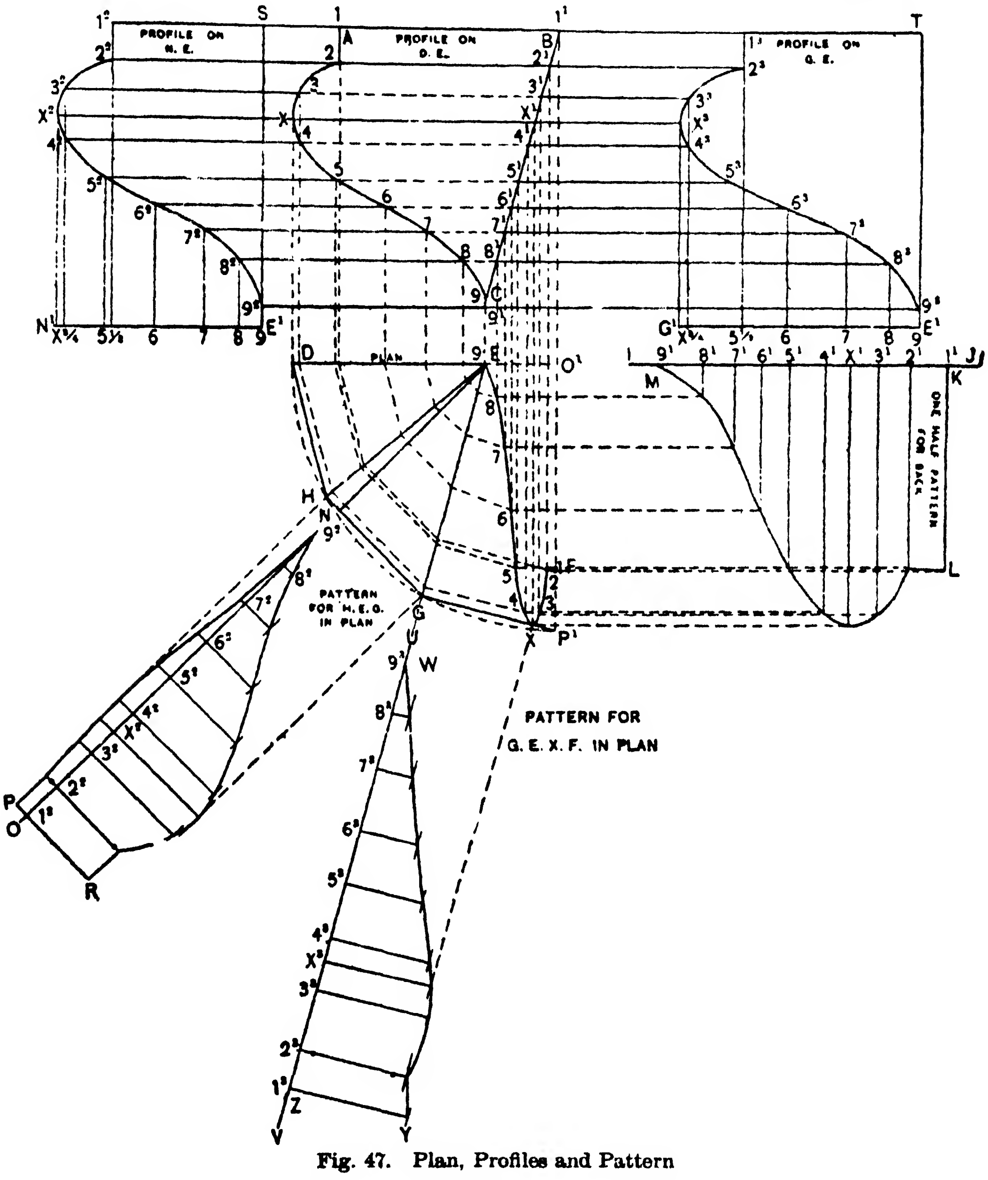


Fig. 47. Plan, Profiles and Pattern

angles to the line of the molding. If, however, a profile was given at right angles to the line of molding, the same principles would be employed. Divide the profile shown from A to C into any number of spaces, as shown by the small figures 1 to

9. At right angles to A B and from these points draw lines, with which intersect the line D E, as shown. From the intersections on the line D E draw lines parallel to D H intersecting the miter line H E, as shown. In the same manner, from the intersections on H E draw lines parallel to H G intersecting the miter line G E.

Now parallel to A B in profile and from the intersections in A C draw lines, as shown, intersecting the slant line B C, as shown by 1^1, 2^1, 3^1, etc. At right angles to A B and from the intersections on B C drop lines intersecting those of similar numbers drawn from the intersections on the miter line G E parallel to G P^1. A line traced through the points thus obtained, as F 1 2 3 X 5 6 7 8 9, will represent the miter line in plan, showing the intersection between the side G P^1 and the slant line B C in elevation. It will now be necessary to obtain true profiles at right angles to the lines of the moldings, to be used for obtaining the stretchouts in the development of the several patterns. At right angles to G P^1 and from the point E draw a line, which in this case happens to coincide with the miter line G E. In the same manner, at right angles to H G and from the point E draw the line N E. Now through the small figures in the profile A C draw lines right and left indefinitely parallel to A B. Take a duplicate of the line N E in plan, with the various intersections numbered to correspond to the various intersections on the profile A C, and place it, as shown by N^1 E^1, parallel to the lines previously drawn. At right angles to N^1 E^1, and from intersections on it draw lines intersecting those of similar numbers drawn from the profile A C. Trace a line through the points thus obtained, as shown. Then will 1^2 X^2 9^2 represent the profile on the line N E in plan. In the same manner take a tracing of G E in plan with the various intersections on it as before described and place it as shown by G^1 E^1. At right angles to G^1 E^1 and through the figures draw lines intersecting those of similar numbers drawn from the profile A C. Trace a line through the intersections thus obtained and 1^3 X^3 9^3 will be the profile on the line G E. For the pattern for that part of the stand shown in plan H E G proceed as follows: At right angles to G H in plan draw the line N O, upon which place the stretchout of the profile on N E, transferring each and every space separately, as shown by the small figures on the line N O. At right angles to N O and through the small figures draw lines which intersect with lines not shown of similar numbers drawn from the miter lines H E and G E. Lines traced through these points, as shown by P N and R N, will represent the pattern of the part H E G. For the pattern for the part shown in plan G E X F proceed in the manner as before described. At right angles to G X draw the stretchout line U V, upon which place the stretchout of the profile on G E. At right angles to U V and through the small figures draw lines, which intersect with

lines not shown of similar numbers drawn at right angles to G X from the intersections on the miter line E X F. Trace a line through the points thus obtained and W Z Y will be the pattern for G E X F. It will be noticed that one side of W Z of the pattern is straight, because the miter line G E in plan is at right angles to X G.

For the profile and pattern for D E H in plan proceed in the manner described in connection with the piece H G E. For the pattern for the back, shown in profile by B C, proceed as follows: Draw any horizontal line, I J, at right angles to O^1 P^1, upon which place a tracing of B C and the various intersections on it, as shown by M K. At right angles to I J and through the small figures draw lines, which intersect with lines of similar numbers drawn from the miter line E X F at right angles to O^1 P^1. A line traced through the points of intersection thus obtained, as shown by M L K, will be one-half the pattern for the back. The other half can be traced opposite the line M K.

MITERS OF MOLDINGS OF DIFFERENT PROJECTION

When a molding of given profile is to miter, at any angle, to a similar molding that has a different projection the method of procedure is as follows: Assuming that M is the given profile as indicated by Fig. 48, and that the wall line has

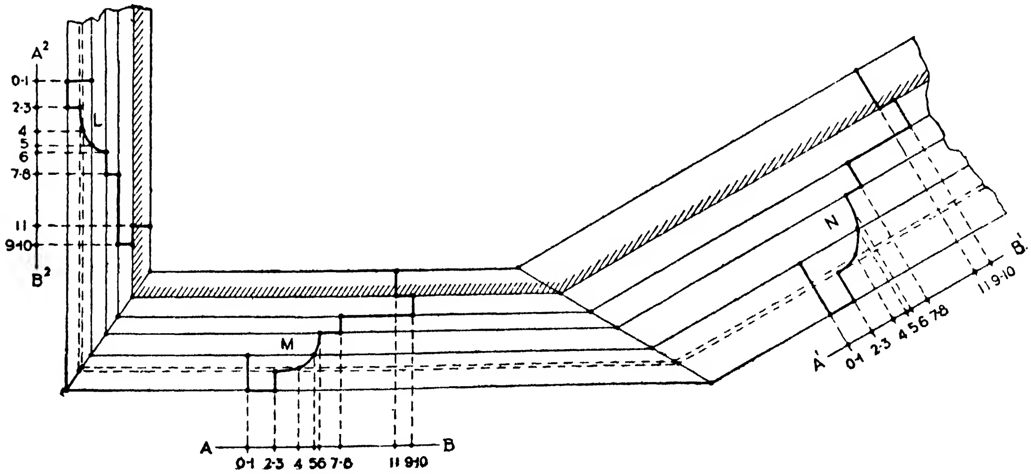


Fig. 48. Plan, True and Modified Profiles

the angles as shown by the cross hatched line; also that the given projections of the two arms of the molding are as shown by the outer line. By drawing a line through the points of intersection of the outer lines and the wall lines the miter line is obtained. To these miter lines, lines are drawn from the profile M and

from the points of intersection on the miter lines and parallel to the wall lines continued for the two arms of the molding.

The hights 0 1 2 3, etc., of profile M are placed on a line as A B, inasmuch as only the projections vary and not the hights. Place duplicate of line A B at the two arms as A^1 B^1 and A^2 B^2. Projecting these hights to the correct lines in both arms and tracing a line through the points of intersection gives the modified profiles of the arms, as L N.

For the patterns, the stretchouts of L M N would be stepped off on a line drawn at right angles to the wall lines for their respective moldings. The usual lines are drawn through the points on these lines which are intersected by lines drawn parallel to the stretchout lines from the points on the miter lines.

THE PATTERN CUT OF THE WASH OF A PEDIMENT

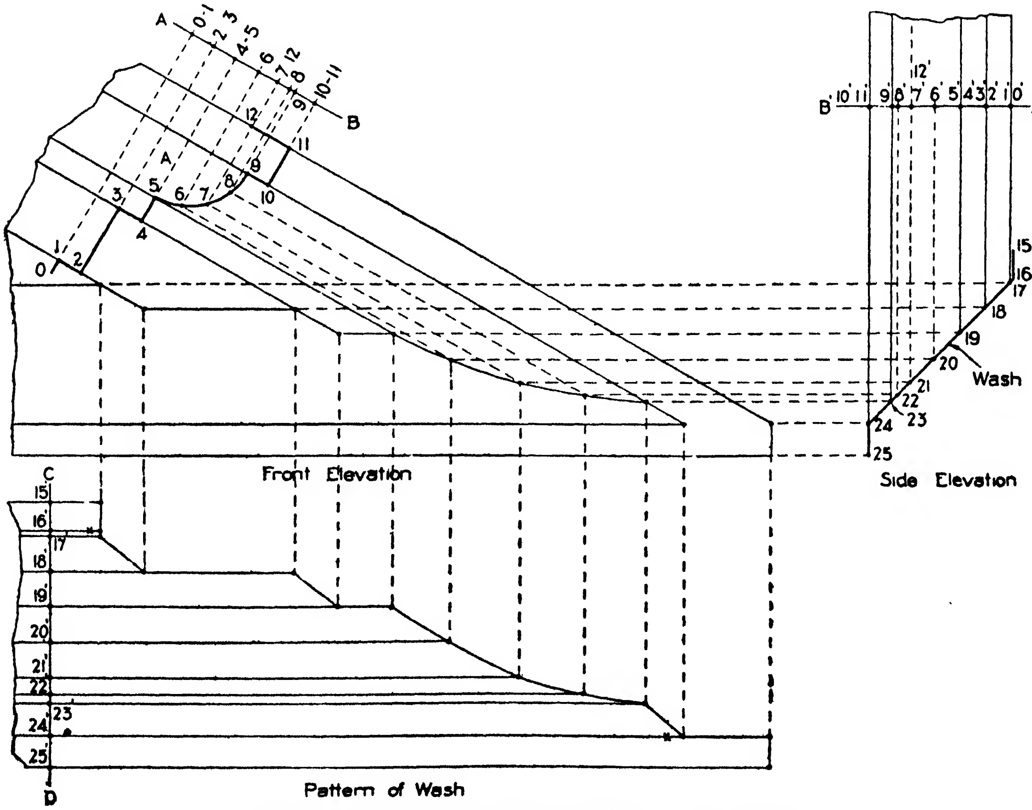


Fig. 49. Elevations and Method of Obtaining Pattern

Though there are many demonstrations of the problems of pediments on a wash, all, apparently, neglect to give the miter cut of the wash. It would im-

measureably facilitate the assembling of the pediment and be truer to profile, for it is an easy matter to dress the wash up to the pediment if the pediment was out of shape; whereas, by soldering to the line or cut on the wash it must come to shape accurately. It does not, therefore, seem out of place to exemplify the procedure for acquiring aforesaid cut, even though the principles are explained in many of the problems.

Fig. 49 indicates a pediment of the profile A mitering on a wash the pitch of which is pronounced to better illustrate the problem. The miter line in the front elevation having been obtained by usual process; draw a line B C at right angles to the horizontal lines of the wash, upon which place the distances 15 16 17 18, etc., of the wash in the side elevation. Draw the usual parallel lines through these points which intersect by lines drawn from the front elevation of similar numbers. A line drawn through these points of intersection will give the miter cut of the wash. It is customary to place laps on the wash cut leaving the cut on the pediment sharp.

PATTERN FOR DROP ON FACE OF SPHERE

The following is an exemplification of the method of obtaining the pattern for the drop A in the accompanying illustration, Fig. 50, and the return strip mitering against the sphere. A B C represents the half sphere, a half plan of which is shown by D E F, H I J shows the projection of the drop around the sphere in plan. Bisect the arcs J I and I H by the points K and L and draw lines from these points to the center X, as shown; then will L^2 K^2 represent one-quarter of the sphere in plan, against which the drop is to miter. From the points L and K in plan and at right angles to H J draw the lines upward intersecting the line A B in elevation at M and N; then within the points M and N construct the drop, as shown by M N O P R. From the points H and J, representing the projection of the drop in plan, and at right angles to H J draw lines intersecting the line A C extended in elevation at U and U^1. Now draw the side view of drop, U T S and U^1 T^1 S^1, the miter line showing the intersection between drop and sphere being omitted in elevation. Having obtained the face of the drop in elevation, the next step is to obtain the line of intersection, or miter line in plan, between the return strip and sphere, for which proceed as follows: Divide one-half the drop shown from O to P into equal spaces, as shown by the small figures 1 to 7; from these points and at right angles to A C drop lines intersecting the arc K 1 in plan at 1, 2, 3, 4, 5, 6, 7, as shown. Now parallel to A C in elevation and from the

small figures on the half drop O P draw lines intersecting the curve of the sphere, as shown by the small dots. From these dots on the curve of the sphere and at right angles to A C drop lines intersecting the center line F D in plan at points 1 to 7. Now with X in plan as center and with radii equal to X 1, X 2, X, 3, etc., describe arcs intersecting vertical lines of similar numbers drawn from the divisions in O P. A line traced through the intersections thus obtained, as shown by X^1 W Y Z K, will be miter line between the half drop and sphere. To complete the drop in plan duplicate the line X^1 W K on the opposite side of the center line X^1 1.

For the pattern for the face of the drop proceed as follows: In line with A C draw the line A^1 B^1, upon which place the stretchout of the arc K 1 in plan, meas-

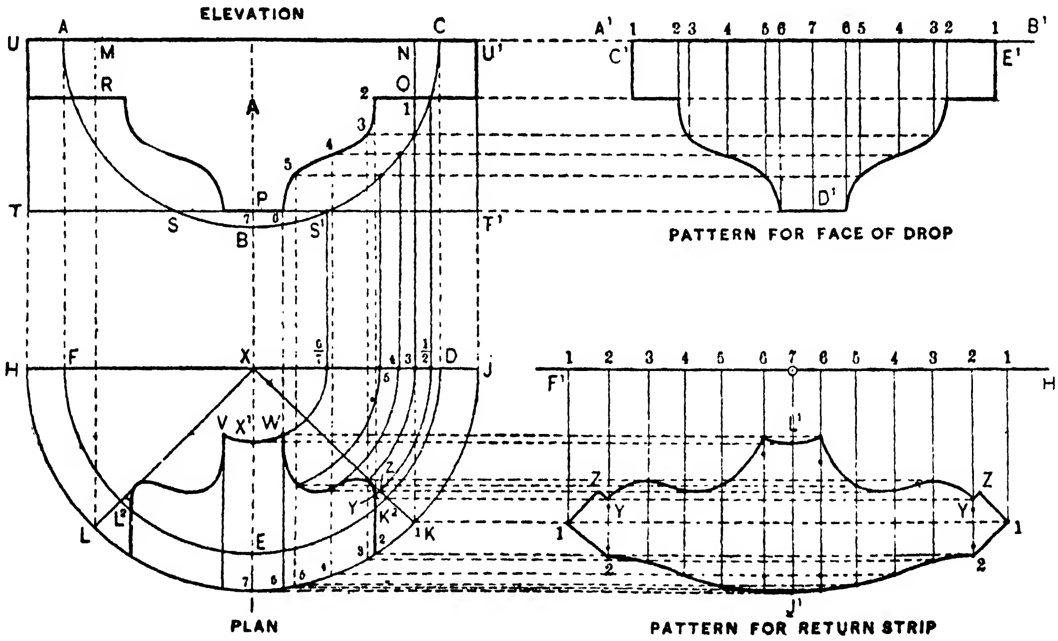


Fig. 50. Method of Obtaining Miter Lines and Pattern

uring each space separate, as shown, from 7 to 1 each way from the center line. Now at right angles to A^1 B^1 and from the small figures draw lines, which intersect with those of similar numbers drawn from the points on O P at right angles to U^1 T^1. A line traced through the points of intersections thus obtained, as shown by C^1 D^1 E^1, will be the pattern for the face of the drop, of which four will be required to inclose the sphere.

For the pattern for the return strip for one of the drops draw any horizontal line, as F^1 H^1, upon which place the stretchout of the half drop 1 to 7 in elevation, measuring on either side of the point 7 on the line F^1 H^1. Now at right angles from

F^1 H^1 and from the small figures draw lines, which intersect with those of similar numbers drawn from the intersections on the line K I and the miter line X W K at right angles to X I. Lines traced through the points of intersection, as shown by 1 Y L^1 1 and 1 2 J^1 2 1, will complete the pattern.

PATTERN FOR A MITER AT DIFFERENT ANGLES

The following deals with the method of developing the pattern of the adjacent miters to the triangle H N G in the plan of Fig. 51. A B C D is the elevation of the article, E F G H J the plan of the base, and K L M N the plan of the top, the miter line in elevation, corresponding with the line N G in plan, being omitted, as

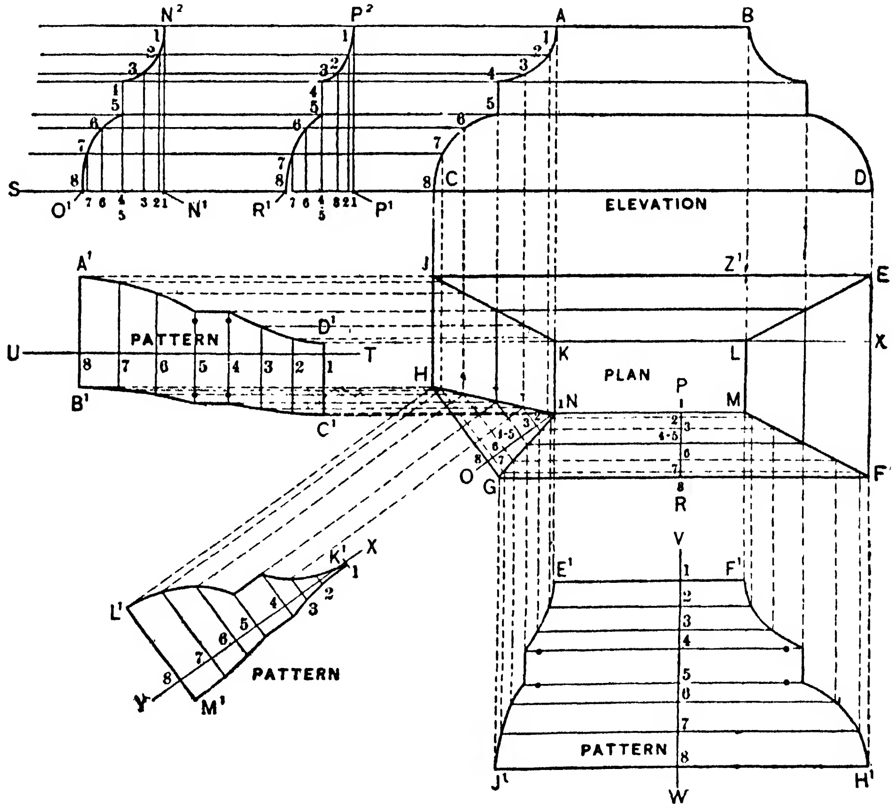


Fig. 51. Plan, Elevation, Profiles and Patterns

unnecessary on the development of the patterns. As every side has a different projection in plan, it will be necessary to obtain profiles for the various sides from which to obtain the stretchout for the developement of the patterns. Divide the profile A C in elevation, which represents the section on the line Z K in plan, into

a number of equal spaces, as shown by the small figures 1 to 8. From these small figures and at right angles to C D draw lines passing through the miter line J K in plan and intersecting the miter line H N. From the points of intersections on the miter line H N and parallel to H G draw lines intersecting the miter line G N; then from these intersections and parallel to G F draw lines intersecting the miter line M F, as shown. Now at right angles to F G and G H draw the lines P R and N O respectively, intersecting the lines drawn from the profile A C. On the line D C in elevation, extended as D S, place a duplicate on the lines P R and N O, including the several points in each, as shown by P^1 R^1 and N^1 O^1 respectively. At right angles to C S and from the various intersections on the lines P^1 R^1 and N^1 O^1 draw lines intersecting those of similar numbers drawn from the profile A C parallel to C D. Trace a line through points of intersections thus obtained, as shown by P^2 R^1 and O^1 N^2 respectively. Then will R^1 P^2 be the section on the line R P in plan and O^1 N^2 be the section on the line O N in plan.

For the pattern for J K N H in plan proceed as follows: At right angle to J H draw the line T U, upon which place the stretchout of the profile A C, as shown by the small figures. At right angles to T U, and through the small figures draw lines, which intersect with those of corresponding numbers drawn at right angles to J H from intersections on the miter lines J K and N H of the plan. Lines traced through intersections thus obtained, as shown by A^1 D^1 and B^1 C^1, will be the pattern for that part shown by J K N H in plan. For the pattern for the triangular part shown by H N G in plan draw at right angles to H G the line X Y, upon which place the stretchout of the profile O^1 N^2, as shown by the small figures. At right angles to X Y and through the small figures draw lines, which intersect with those of similar numbers drawn from the intersections on the miter lines H N and N G of the plan at right angles to H G. Lines traced through the points thus obtained, as shown by K^1 L^1 and K^1 M^1, will be the required pattern.

For the pattern for that part shown by N M F G draw V W at right angles to G F, upon which place the stretchout of the profile R^1 P^2, as shown by the small figures. At right angles to V W and through the small figures draw lines, which intersect with those of similar numbers drawn from the miter lines G N and M F at right angles to G F. Lines traced through points thus obtained, as shown by E^1 J^1 and F^1 H^1, will be the required pattern.

For the pattern for that part shown by M L E F proceed in similar manner, obtaining the stretchout of the profile B D, which is the same as A C, and for the pattern for the part L K J E obtain the stretchout for R^1 P^2 because the projection L Z^1 is equal to P R.

PEDIMENT CHART

The accompanying diagrams and descriptions show a method of laying out pediments of any size, without going to the trouble of drawing full size details. They also show a method of laying out pediments of different lengths, having the same rake and profile, using but one pattern, as indicated in Fig. 53, and the pediment chart shown in Fig. 54. Referring to the diagrams, let Fig. 52 represent a front elevation of a cornice drawn to a scale of ½ inch to the foot, the hight of the cornice being 4 feet, and including the pediment 6 feet 8 inches. There is also shown in Fig. 52 the measurements of the brick piers and window openings, besides the brackets spaced to set over the brick piers, the correct lengths of the pediment and crown moldings returns being given. In this connection it may not be out of place to show how the divisions between the brackets and the lengths of the pediment and crown moldings are determined.

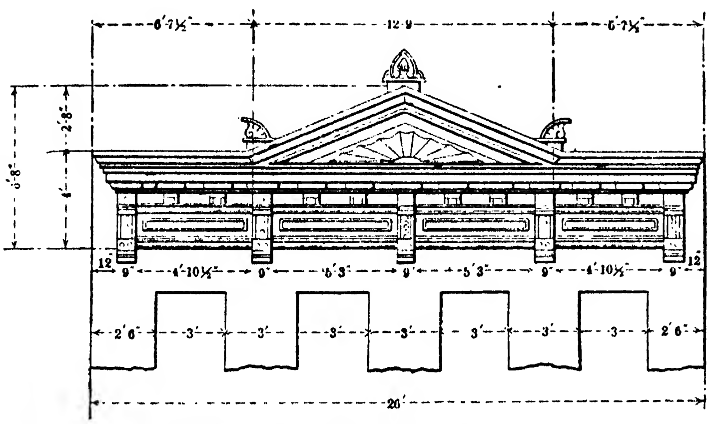


Fig. 52. Front Elevation of Cornice

As shown in Fig. 52, the width of the window openings is 3 feet, the end piers 2 feet 6 inches and the middle piers 3 feet, thus making the total width of the building 26 feet. The width of each of the brackets is 9 inches, and the projection of the cap and crown moldings over the sides of the end brackets on each side is 12 inches.

As shown on the elevation, Fig. 52, the three center brackets are to set over the center of the brick piers, and the two end brackets are to set 12 inches from the line of the wall on each side.

To figure these divisions proceed as follows: Referring to Fig. 52, add the width of the end pier, 2 feet 6 inches, the width of the window opening, 3 feet, and one-half of the second brick pier, which is 1 foot 6 inches, the total of which amounts to 7 feet. Now add the distance that the end brackets sets from the wall line, which is 12 inches, the width of the bracket, 9 inches, and one-half width of the second bracket, which is 4½ inches, and amounts to 2 feet 1½ inches; deduct the 2 feet 1½ inches from the 7 feet before obtained, and there remains 4 feet 10½ inches, which is the distance between the brackets for the two ends of the cornice,

as shown. For the two center spaces, add the one-half of the second pier, which is 1 foot 6 inches, the width of the window opening, which is 3 feet, and one-half of the center pier, which is 1 foot 6 inches, the total of which amounts to 6 feet. Now add one-half of the second bracket, which is 4½ inches, the one-half of the center brackets, which is 4½ inches, and amounts to 9 inches; deduct the 9 inches from the 6 feet before obtained, there and remains 5 feet 3 inches, which is the length for the two divisions in the center of the cornice, as shown.

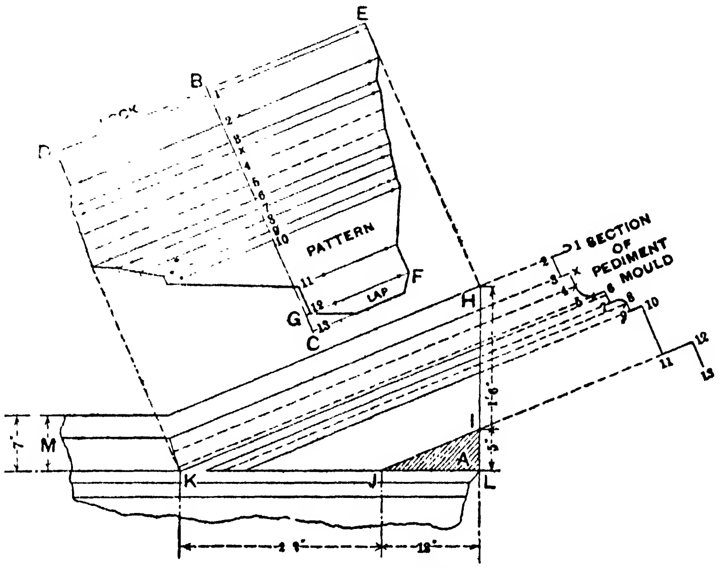


Fig. 53. Enlarged View of Part of Pediment

If these divisions are figured correctly, the total should amount to 26 feet. Now, to obtain the lengths of the pediment and crown moldings, proceed as follows: Referring to Fig. 53 note the intersection K. This intersection K should come plumb over the outside line of the two brackets, as shown by the dotted lines in Fig. 52. Now, by adding the widths of the three center brackets, which amount to 2 feet 3 inches, and the two center divisions, which amount to 10 feet 6 inches, there will be 12 feet 9 inches, which gives the length of the pediment from intersection to intersection, shown by the dotted lines in Fig. 52. For the length of the two end crown moldings add the end space, 4 feet 10½ inches, the width of the bracket, 9 inches, and the space of 12 inches, the total of which amounts to 6 feet 7½ inches, as shown.

Now, if these lengths have been correctly figured the amount should be 26 feet. The panels are usually given 3 inches margin from the side of the brackets; then is each panel 6 inches shorter than the spaces shown between the brackets; the modillions are easily spaced after the brackets are in position. To illustrate the use of the pediment chart shown in Fig. 54, suppose that Fig. 52 is an architect's drawing, from which is to be drawn a full size detail, omitting the full size detail of the pediment and using instead the pediment chart, which is drawn to one-third full size, the chart being drawn full size in practice.

First obtain the bevel of the pediment shown in Fig. 52, as shown by A in Fig. 53, and make the base or horizontal line J L in Fig. 53 12 inches; draw the bevel or slant line J I indefinitely until it intersects the perpendicular line I L, drawn at right angles to J L, as shown. The diagram in Fig. 53 is drawn to a scale of ½ inch to the foot, and shows the hight of the perpendicular line I L to be 5 inches, or in other words, that the one-half pediment shown in Fig. 52 has a rise of 5 inches to every 12 inches of base.

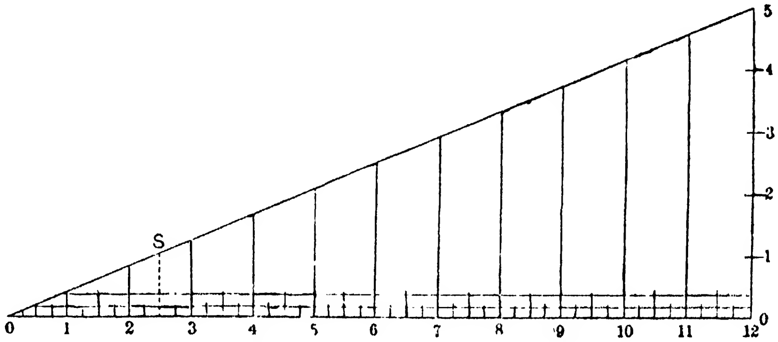


Fig. 54. Pediment Chart

Fig. 54 represents the pediment chart and is an enlarged view of the triangle A in Fig. 53, and shows how the base line J L in Fig. 53 should be divided into quarters, halves and inches. In practice it is not necessary to draw an extra chart as shown in Fig. 54, but make the divisions of inches direct upon the chart, as indicated by A in Fig. 53. The bevel I J L in Fig. 53 being correct, the pattern for the pediment is obtained direct from this bevel in the usual manner, as shown in Fig. 53, and needs no further explanation. In this case the hight of the miter cut H I in Fig. 53 will be 1 foot 6 inches, and the length of the miter cut on the horizontal line K J will be 2 feet 2 inches. Having obtained these measurements in practice, it is now in order to figure out the backgrounds and pediment moldings of any length pediment having the same rake and profile without making any further details, but simply using the chart shown in Fig. 54 and the pattern shown in Fig. 53. The chart, as before explained, should be at A in Fig. 53. Thus, to obtain the sizes of the background and moldings for the pediment shown in Fig. 52, with but 12 inches of detail, proceed as follows: The length of the pediment in Fig. 52 from intersection to intersection is 12 feet 9 inches; the miter cut on the horizontal line from intersection K to J in Fig. 53 is 2 feet 2 inches; twice 2 feet 2 inches is 4 feet 4 inches. Deducting 4 feet 4 inches from 12 feet 9 inches leaves 8 feet 5 inches. One-half of 8 feet 5 inches equal 4 feet 2½ inches, as shown in Fig. 55, and gives the length of one-half of the base of background. The rise of one-half of the pediment is 5 inches to the foot, as shown on the chart in Fig. 54. If 1 foot rises 5 inches, 4 feet will rise 20 inches, and 2½ inches will rise as much as is shown in Fig. 54 where the dotted line intersects the hypotenuse at S, which is

1 1-24 inches (in practice the 1-24 inch can be omitted, which has been done in this case), thus making the total rise 1 foot 9 inches for 4 feet 2½ inches of the base, as shown in Fig. 55. Then will Fig. 55 represent one-half of the background of a pediment having the length and bevel shown in Fig. 52. For the length and miter cuts of the pediment moldings use the pattern shown in Fig. 53, and measuring on the line G F make G F in length equal to the slant line or hypotenuse of the background shown in Fig. 55, making similar miter cuts at each end of the molding, as shown on pattern in Fig. 53.

The hight of the background in Fig. 55 is 1 foot 9 inches, and the hight of the miter cut H I in Fig. 53 is 1 foot 6 inches, the total of which amounts to 3 feet 3 inches; deduct the 7 inches, being the amount of the molding M in Fig. 53, giving 2 feet 8 inches as required for the entire hight of the pediment as shown in Fig. 52. By saving for future use the pattern and chart, any length pediment can be quickly laid out; and if a different design of cornice is used, the same pediment can be employed. By using the same rake, the bevel on the ornaments shown in Fig. 52

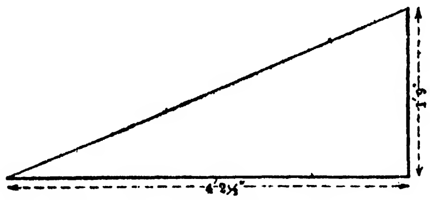


Fig. 55. One-Half of Metal Background

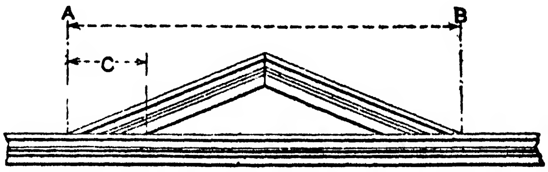


Fig. 56. Pediment on a Horizontal Molding

need not be changed. For example, if the length of the pediment was 16 feet 4 inches, instead of 12 feet 9 inches, as shown in Fig. 52, deduct twice the length of K J in Fig. 53, which is 4 feet 4 inches, from 16 feet 4 inches, which leaves 12 feet or the base length of the background. One half of 12 feet equals 6 feet; 1 foot rising 5 inches, 6 feet would rise 30 inches, or 2 feet 6 inches, or the center hight of the background. The length of the moldings would be obtained from the hypotenuse or slant line of the background, using the pattern and miter cuts shown in Fig. 53, measuring on the line G F for the length of the moldings. After once having the chart and patterns the measurements are quickly obtained.

It may be required to know what the hight of a pediment of this length would be above the top of the crown molding of a cornice. The procedure being: The center of the background rises 2 feet 6 inches, as before explained, and the miter cut H I in Fig. 53 is 1 foot 6 inches, making the total hight 4 feet; deduct the 7 inches, being the hight of the molding M in Fig. 53, which leaves the hight of the pediment 3 feet 5 inches from the top of the crown molding to the apex. In Fig.

52 a pediment is shown which intersects with the horizontal crown molding, while in Fig. 56 is shown a pediment entirely above a horizontal molding. The chart shown in Fig. 54 is applicable for both forms of pediment, it only being necessary to know the length of A B in Fig. 56, and from this length to deduct twice the width of the miter cut C on the horizontal molding, following the rules as before explained, or as explained further on.

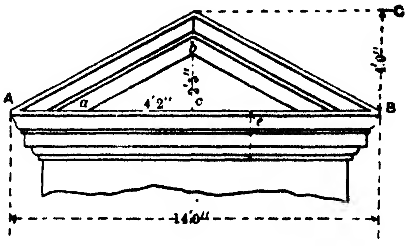


Fig. 57. Elevation of Pediment

To illustrate the time and labor saved by using the pediment chart, as shown in Fig. 54, it is cited that a cornice similar to Fig. 52, having a pediment 22 feet 4 inches in length, and having a rise of 4½ inches to the foot, was made in accordance with this method. To draw to full size one-half of this length pediment, so as to get the correct dimensions of the background, it would have required 11 feet 2 inches of space or drawing paper; whereas as shown in Fig. 54 a triangle only was required 12 inches in length, having the correct bevel, from which the pattern, base and rise of the pediment background was obtained as before explained, and from the hypotenuse or slant line of the background the length of the pediment molding was obtained.

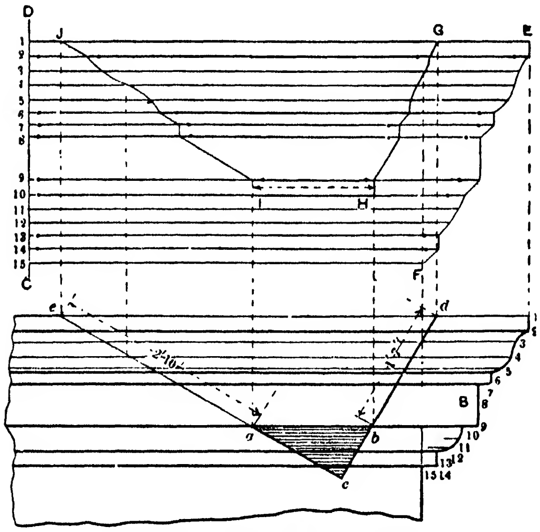


Fig. 58. Obtaining the Patterns

Fig. 57 represents the elevation of a raking pediment or gable on a horizontal cornice. It is now desired to find the size of the flat triangle *a b c* without drawing the full size pediment. The method usually employed is to strike a chalk line, A *c*, equal to 7 feet, and another from *c* to *b*, at right angles to A *c*, equal to 4 feet, and draw a line from the apex *b* to A. Then deduct the width of the mold and draw *a b*.

The short method is shown in Fig. 58. After the detail of the horizontal mold *e* in Fig. 57 has been drawn, as shown by B in Fig. 58, simply take a tracing of the triangle *a b c* in Fig. 57, no matter to what scale it has been drawn, and place it on its proper line, as shown by *a b c* in Fig. 58, and extend the lines *c b* and *c a* until they intersect the top line of the mold at *d* and *e*, respectively. *a b* has been placed on the line 9 because the pediment mold in Fig. 58 is similar to the part of the

horizontal mold *e*. Then assuming that the distances *e a* and *b d* were 2 feet 10 inches and 1 foot 7 inches, respectively, on the full size, then simply deduct these amounts from 7 feet and 4 feet in Fig. 57, leaving the base of the triangle 4 feet 2 inches and the altitude 2 feet 5 inches, which is laid out directly on a 30-inch sheet, thereby obtaining the two triangles from one rectangular sheet. Having the miter lines in position in Fig. 57, obtain three miter cuts on one drawing by dividing the profile B and drawing lines as shown. Place the stretchout of B on C D, and obtain the miter patterns in the usual manner. Then E F is the pattern for the returns at A and B in Fig. 57, G H in Fig. 58 the cut for the miter *b* in Fig. 57, and J I in Fig. 58 the cut for the miter A *a* in Fig. 57. Then, knowing the length from *a* to *b*, which is obtained by measuring that line on the metal, lay out the pediment mold of similar length, measuring from I to H in Fig. 58.

INSIDE MITER OF A RAKING MOLDING

Although the principles for a problem of this nature are elucidated in Raking Moldings II and IV, the demonstration of the method of procedure, for acquiring the miter line in elevation and the raked profile, is here presented as an additional aid in the study of the principles. Assume that the angle in plan is as shown by Fig. 58a, and that the gable slant is as shown; also that the normal profile is as shown by R. If the normal profile was given for the gable, the procedure would be identical; that is, the normal profile would be placed in the gable and the process reversed, as it were. The normal profile was placed in the horizontal molding inasmuch as in the majority of cases, the horizontal molding has the given profile.

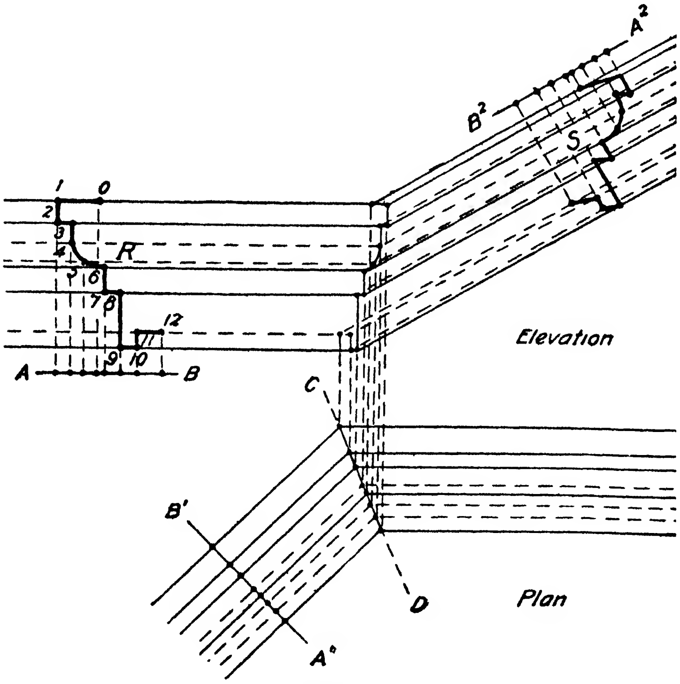


Fig. 58a. A Method of Procedure

Divide and number profile R as shown, and draw lines through the points toward the miter. In the raking of the profile for the gable the projections or

widths of the profile do not change, the hights only; hence drop lines from the points in the profile R to any line as A B. Place this line in the plan as indicated by A′ B′, being careful to have the front of the profile, which is A, to the front of the plan. Draw lines to the miter line in plan from this line and where they intersect it, project lines upward until they intersect like numbered lines from profile R in the elevation. A line traced through these points of intersection will give the miter line in elevation.

From these points in the miter line draw lines parallel with the slant of the gable. Place the line A B parallel with the gable as shown by A^2 B^2 and drop lines to intersect lines of similar numbers in the gable; a line traced through these points of intersection will be the raked profile of the gable as indicated by S. The patterns would be developed precisely as for Problem IV on page 965.

RAKING MOLDINGS—I

In these twelve articles will be described the method of developing the various raking moldings arising in practical work. Twelve developments are to be given to cover any problem which may be encountered in the shop. The text covering these twelve problems will be as brief as possible, but the drawings will be arranged so that the various parts will be easily understood by referring to similar reference letters or figures. The principles will be explained so that they are applicable to any form, whether the molding runs straight or circular or whether the plan has a square or other return.

Fig. 59, of Problem I, shows the development of raking molding, with right angle horizontal returns at top and bottom, when the normal or given profile is in the rake. Having established the proper angle of the rake, as shown by 7 7° T in the half elevation, place the normal profile (A) in its proper position as shown, and divide the profile into an equal number of spaces as shown from 1 to 10. Through the points in (A) draw lines indefinitely parallel to the raking molding. Upon the line X Y, which is drawn parallel to the rake, place the various projections of the profile (A) as shown. Having established the point 7° in elevation, place the various projections on X Y in a horizontal position as shown by X^1 Y^1,

being careful that the point 7 on X^1 Y^1 comes directly on a vertical line below the point 7° in elevation as shown.

In similar manner, having established the point 7 in the upper return in elevation, place the projections on X Y, as shown by X^2 Y^2, being careful to have the point 7 on X^2 Y^2 come directly in a vertical line above 7 in elevation as shown. Now from the various points in X^1 Y^1 and X^2 Y^2 draw perpendicular lines which intersect with similar numbered lines drawn through the profile (A). Trace lines through points thus obtained. Then will (B) be the modified profile for the lower return and (C) the modified profile of the upper return.

In its proper position below the elevation is shown a half inverted plan N^1 O^1 M^1 K^1 which, however, is not necessary in the development of the patterns, but is only shown to make clear the principles which must be followed when the returns are other than right angles. Thus it will be seen that (A) in plan is a reproduction of (A) in elevation. From the intersections in (A) in plan horizontal lines are drawn, cutting the miter lines O^1 V and M^1 U. Lines are then erected, cutting similar lines drawn parallel to the rake in elevation, and resulting in similar modified profiles (B) and (C).

For the three patterns proceed as follows: For the lower return pattern take the girth of the profile (B) and place it on the horizontal line N^2 P^2 as shown. Draw the usual measuring lines which intersect by lines drawn from similar intersections on the miter line O^1 V. Trace a line through points thus obtained when N^2 O^2 R^2 P^2 will be the lower return pattern. This same pattern could be obtained without the use of the plan by placing the girth of B on the vertical line N P, drawing the usual measuring lines and intersecting them by lines drawn vertically from similar numbers in the profile (B) and making the distance O N equal to O^1 N^1 in plan. Then O N P R would also be the pattern for the lower return.

The pattern for the upper return is also obtained by the short method, that is, by placing the girth of (C) upon the vertical line K L, drawing the usual measuring lines and intersecting them by lines drawn from similar numbers in the profile (C), and making K M equal to K^1 M^1 in plan. K M L is then the pattern for the upper return.

For the pattern for the rake molding take the girth of (A) and place it on the line D E, which is drawn at right angles to the raking molding. Through D E draw the usual measuring lines which intersect by perpendicular lines drawn from similar numbers in the modified profiles B and C and resulting, when a line is traced through points thus obtained, in the pattern shape F G H J. No matter what profile or angle the rake may have, these principles are applicable to any case.

DEMONSTRATED PATTERNS

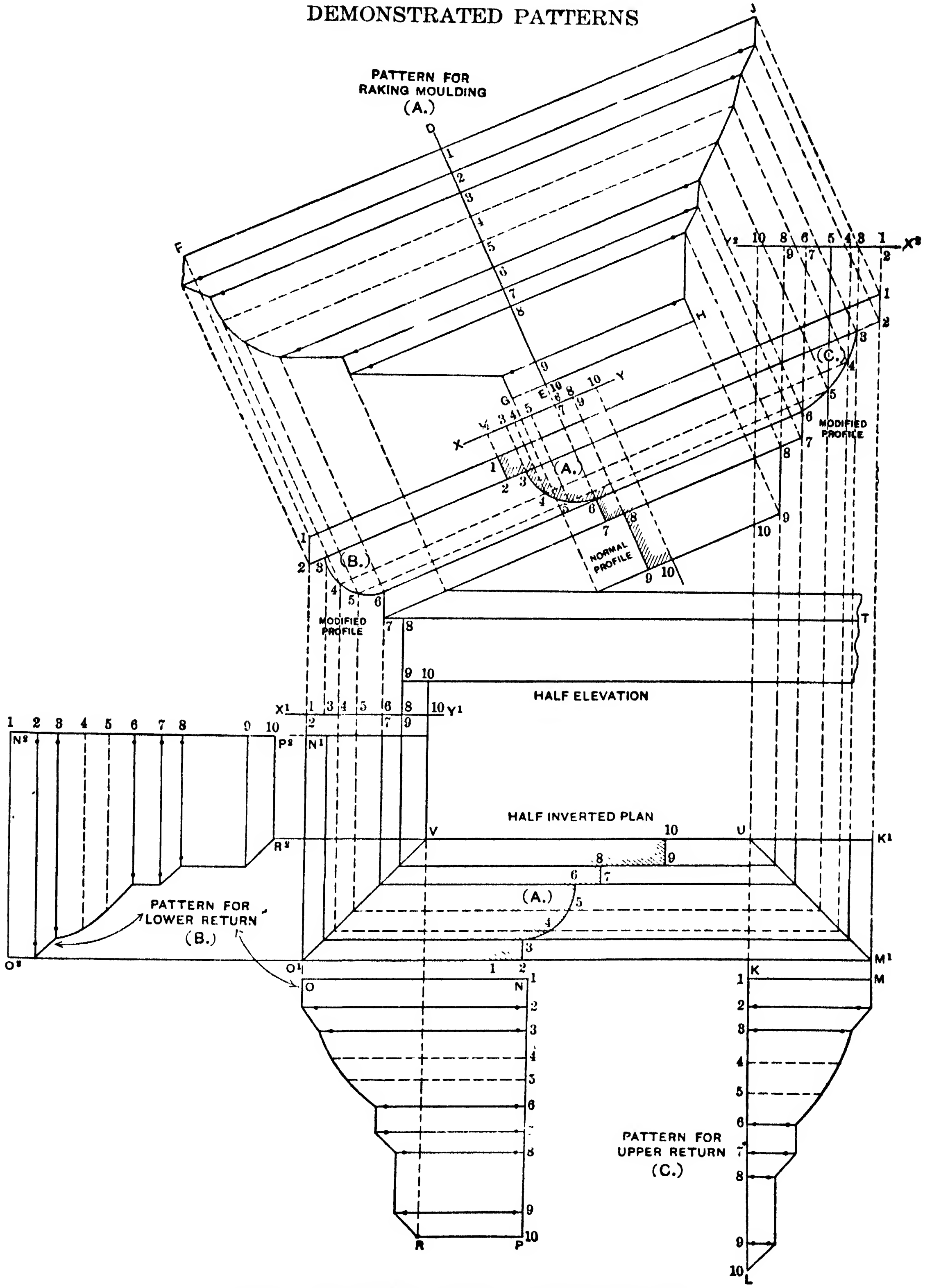


Fig. 59. Drawings for Problem I on Raking Moldings

RAKING MOLDINGS—II

Problem II shows the development of a raking molding, with the normal profile placed in the rake, with a lower horizontal return at other than a right angle. In this case a plan must be used when developing the horizontal return. In this case the upper return would be a right angle, and as this pattern was developed in in Problem I, it is omitted here.

In Fig. 60 first establish the angle S 7′ T, and from 7′ drop a vertical line, intersecting any horizontal line drawn below the elevation, as shown by 7°. Draw the angle as desired, as shown by $b7^{\circ}a$. Bisect this angle as follows: With 7° as center, draw any desired arc as ab. Using the same radius, with a and b as centers, intersect arcs at c. Now draw the miter line $c7^{\circ}K^1$. Place the normal profile A in elevation as shown, which space in equal parts. Through this division parallel to 7 S draw lines indefinitely, as shown.

Take a duplicate of A and place it in its proper position in plan, being careful that point 7 in the profile in plan comes upon the line drawn from 7°. Through A in plan draw lines parallel to 7° 7 until they intersect the miter line cK^1, as shown from which lines are erected intersecting similar lines drawn through A in elevation and resulting in the miter line shown from 1′ to 10′. From the intersections 1′ to 10′ draw horizontal lines, which intersect by vertical lines dropped from the projections on X^1Y^1, which were obtained from XY in the normal profile A. A line traced through the intersections 1 to 10 in B is the modified profile for the horizontal return. Complete the part inverted plan by making K^1J^1 the desired length.

For the pattern for the lower cut of the raking molding, take the girth of the normal profile A and place it on the line CD drawn at right angles to the rake, through which parallel lines are drawn, as shown, and intersected by lines drawn from similar numbers in the miter line 1′ 10″ at right angles 7 S. A line traced through points thus obtained, as shown by EF, will be the desired cut.

For the pattern for the horizontal return, take the girth of the modified profile B and place it on the line HJ drawn at right angles to J^1K^1 in plan. Through the divisions on JH lines are drawn parallel to J^1K^1 and intersected by lines drawn at right angles to J^1K^1 from similar intersections on the miter line cK^1. Trace a line through points thus obtained; then JKLH is the pattern desired.

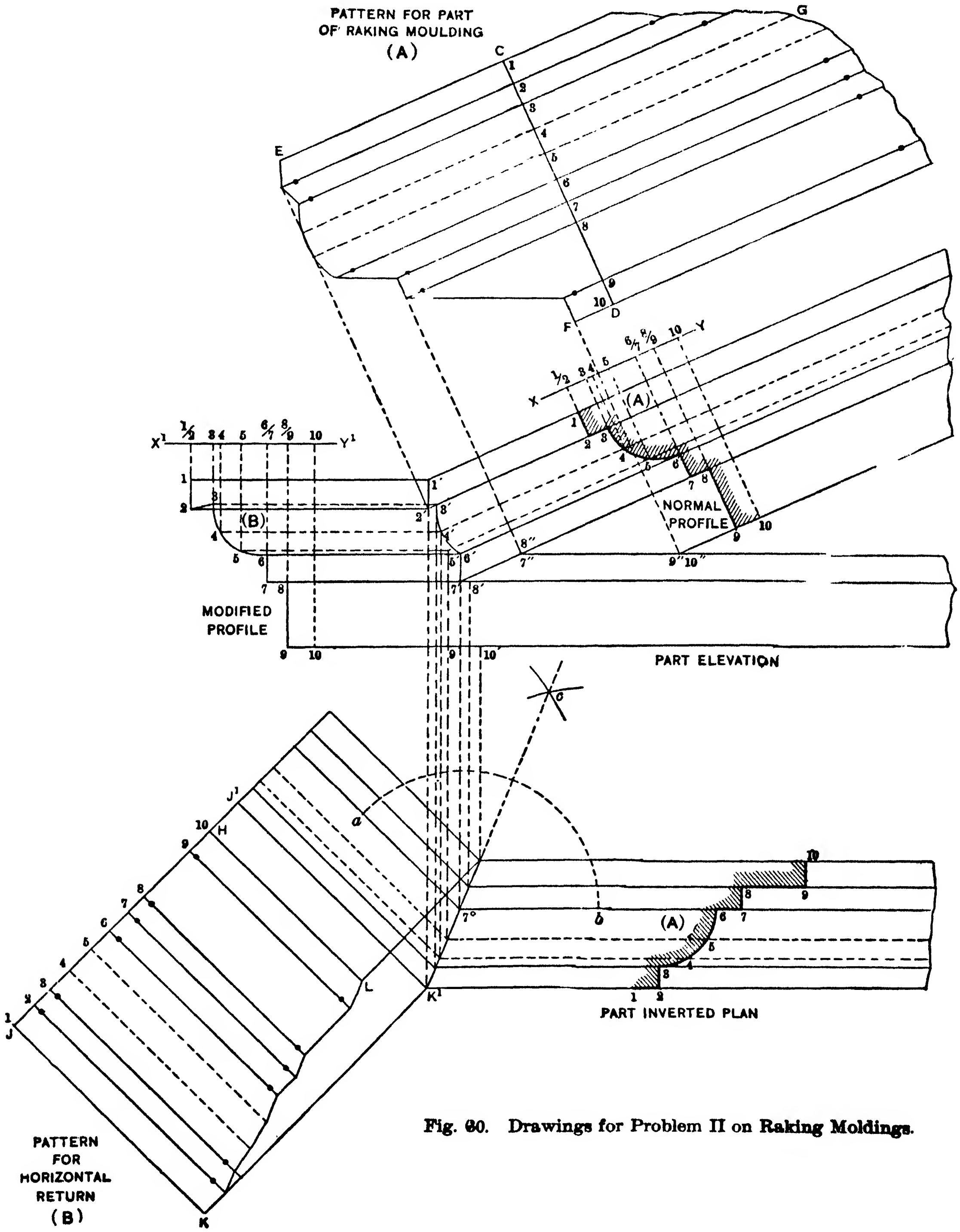


Fig. 60. Drawings for Problem II on Raking Moldings.

RAKING MOLDINGS—III

Problem III shows how the various patterns are obtained, when the normal or given profile is placed in the lower return A, and it becomes necessary to find the modified profile for the raking molding B and upper return C as shown by Fig. 61. Should, however, the normal profile be given in the upper return C, the modified profiles for the inclined and lower moldings would be found in precisely the same manner as that which will follow.

Having drawn the normal profile A, complete the half elevation, drawing the horizontal and inclined lines indefinitely, as shown. Divide the profile A into equal spaces, as shown, from which erect vertical lines on *a b*, as shown by similar numbers. Take a tracing of *a b* and place it parallel to the raking molding, as shown by *a′ b′*. At right angles to *a′ b′* and from the various numbers draw lines, which intersect by lines parallel to the raking molding from similar numbered intersections in the normal profile A. Trace a line through points thus obtained; then will B be the modified profile for the raking molding.

Establish at will the point 1 of the upper part of the raking molding and place a duplicate of the projections on *a b*, as shown by *a″ b″*, being careful that the point 1 on *a″ b″* comes directly over 1. Now drop vertical lines from *a″ b″*, intersecting similar numbered lines in elevation and resulting in the modified profile C.

The patterns for the raking and upper and lower returns are obtained as shown. As the returns run at right angles, the girth of A is placed upon the vertical line D E and the girth of C upon the vertical line A B. Measuring lines are drawn and intersected by lines drawn from similar figures in the profiles A and C, respectively. Then A B C is the pattern for the upper return and D E F G the pattern for the lower return.

The girth of B is now placed on the line H J, drawn at right angles to the inclined molding, measuring lines drawn, and intersected by lines drawn from similar intersections in A and C. L M N O is then the pattern for the raking molding. In obtaining the length of the upper and lower returns measurements are taken from the plan in Problem I, or they can be made any length required.

RAKING MOLDINGS—IV

In this problem is shown how the patterns are obtained when the normal profile is in the lower return, the latter forming an angle other than a right angle, while the upper return is a right angle. First draw the plan in Fig. 62 showing

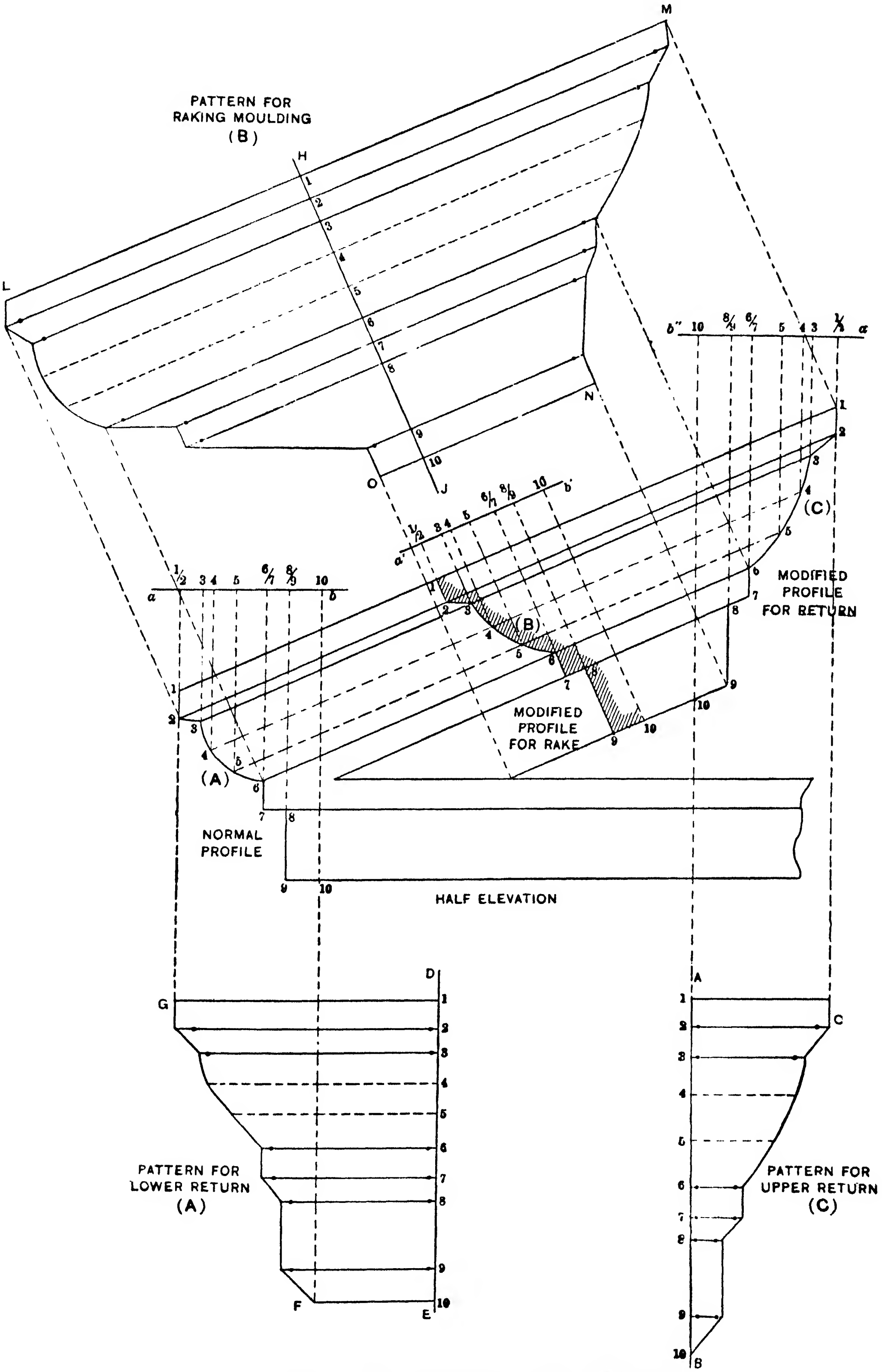


Fig. 61. Drawings for Problem III on Raking Moldings

the proper angle of the lower and upper returns, and place in its proper position, in plan, a profile of the normal or given profile as shown by A. Obtain the miter line by bisecting the angle as shown by *a*, *b*, c and draw the miter line *c* D^1.

Divide the profile A in plan into a number of equal spaces, as shown from 1 to 10, through which draw lines parallel to the lower return A^1 D^1 until they intersect the miter line *c* D^1, as shown. From 6° erect the vertical line intersecting any horizontal line in elevation at 6^T. From the joint 6^T draw the angle of the rake as shown. Now place a duplicate of the profile A in plan as shown by A in elevation, being careful that the point 6 in the profile comes on the horizontal line drawn from 6^T.

From the various intersections in A of the elevation, draw horizontal lines which intersect by vertical ones erected from similar intersections on the miter line *c* D^1, resulting in the miter line in elevation shown from H to J. From the various intersections in H J draw lines parallel to the rake indifinitely. Now draw any horizontal line, *d e*, upon which obtain the projections of the various points in the profile A, as shown, and place them parallel to the rake, as shown by *d' e'*, at right angles to which draw lines intersecting similar numbered lines and resulting in the modified profile for the rake B. In similar manner take a tracing of *d e* and place it on a horizontal line, as shown by *d'' e''*, being careful that 1-2 comes directly over the desired position in elevation of 1-2 of the upper return. Drop vertical lines from the various points on *d'' e''* until they intersect similar numbered lines drawn parallel to the rake. Trace a line through points thus obtained resulting in the profile C.

For the pattern for the upper return take the stretchout of the profile C and place it on the vertical line G F, from which draw the usual measuring lines, which intersect by vertical lines dropped from similar points in (C). Make the distance E G in the pattern equal to the return E^1 G^1 in the plan. Then E G F is the pattern for the return (C). For the pattern for the lower return take the stretchout of either profile (A) and place it on the line A A^1 drawn at right angles to A^1 D^1.

Draw the usual measuring lines which intersect by lines drawn from similar numbers on the miter line *c* D^1, and resulting in the pattern shown by A B C D.

The pattern for the raking molding is obtained by placing the girth of B on any line drawn at right angles to H 1, drawing the usual measuring lines, and intersecting same by lines drawn at right angles to H 1 from the intersections on the miter line H 9-10 and the profile C, thus resulting in the pattern L M N O.

DEMONSTRATED PATTERNS

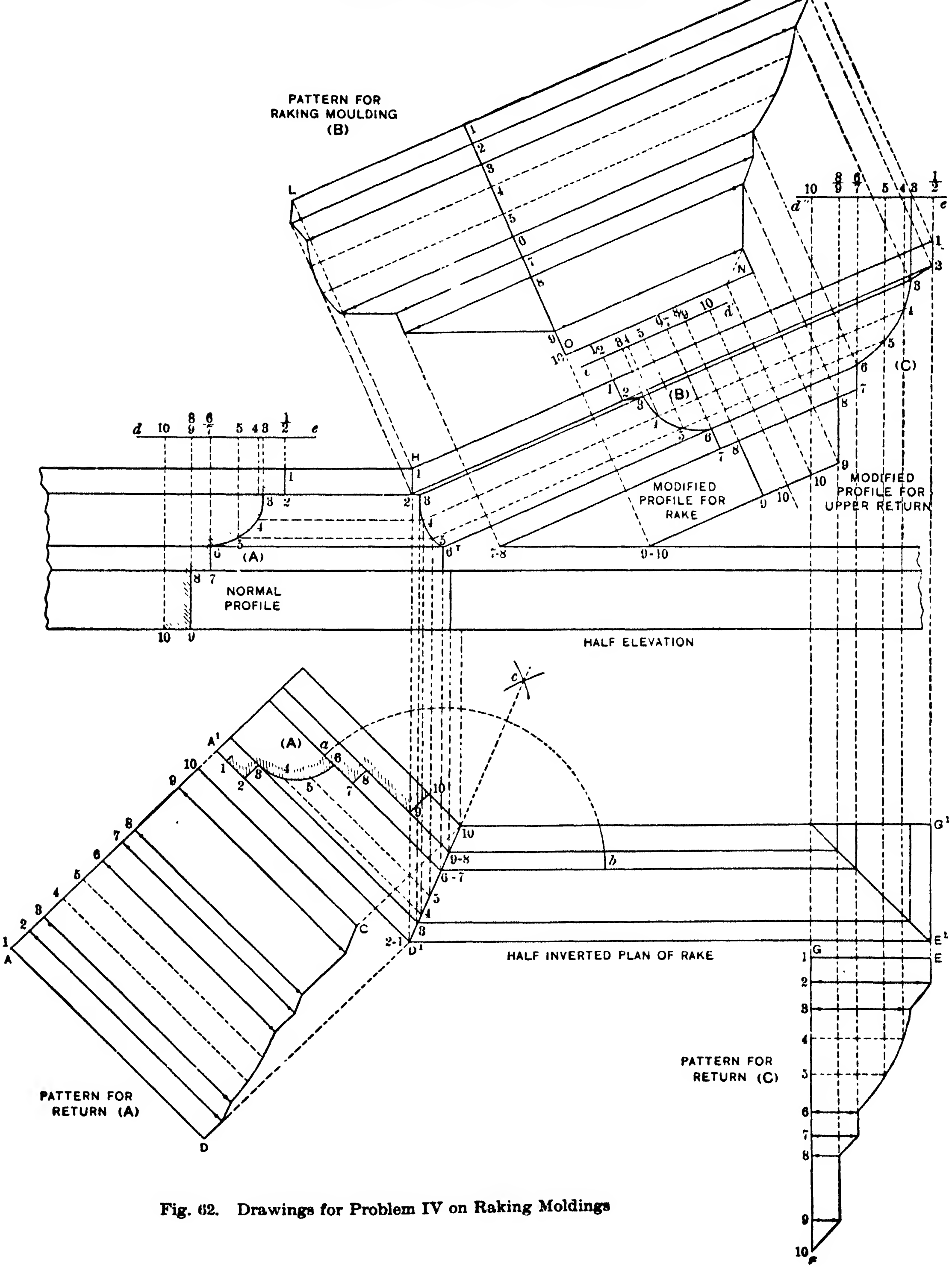


Fig. 62. Drawings for Problem IV on Raking Moldings

RAKING MOLDINGS—V

Problem V shows how the pattern for the lower right angle return is obtained when it miters with a curved molding with the normal profile in the horizontal return, as shown by D F in Fig. 63. Place the normal profile in its proper position

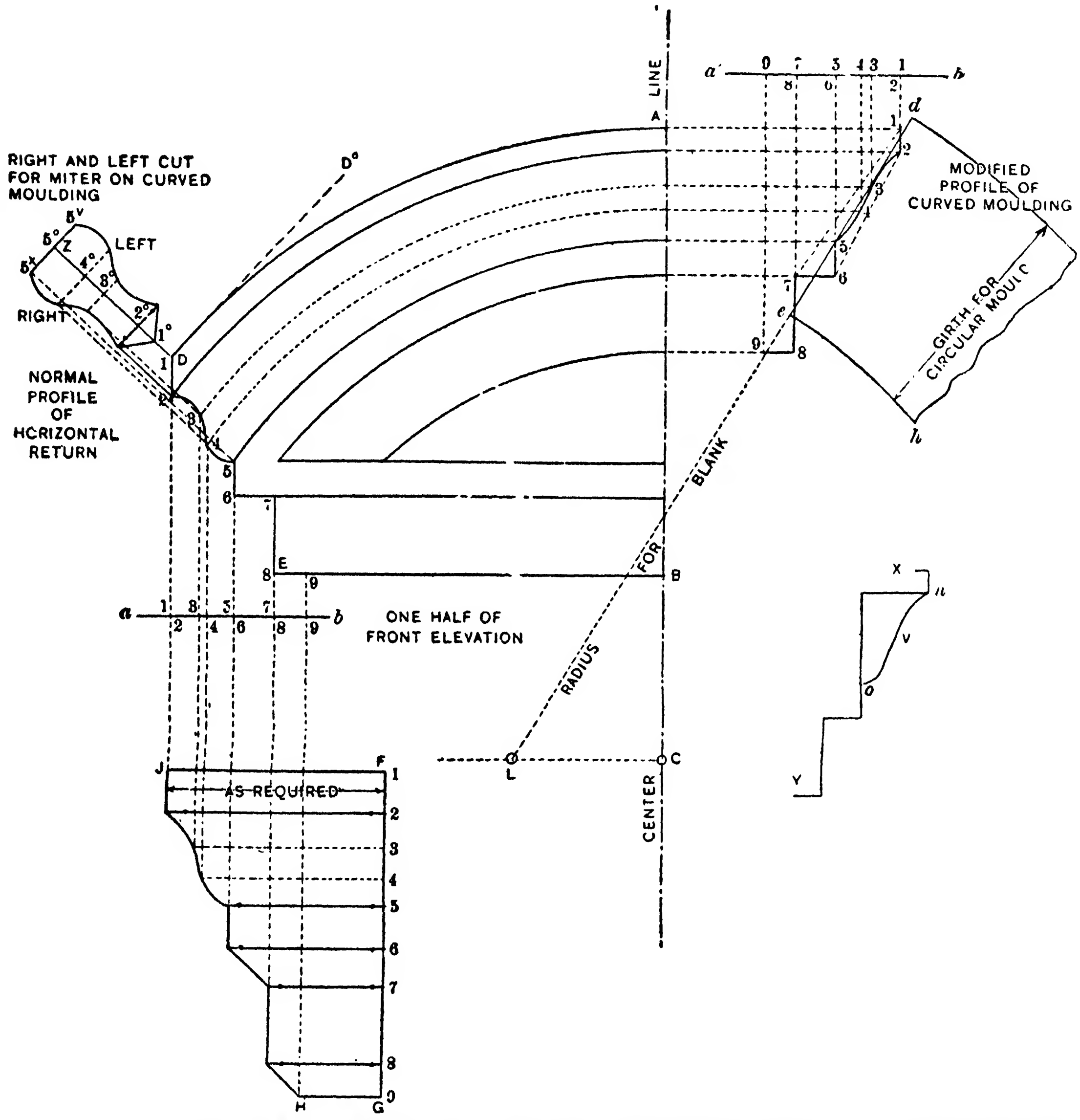


Fig. 63. Drawings for Problem V on Raking Moldings

from the center line in elevation, and with the required radii and C on the center line as center draw the arcs shown and complete the one-half front elevation.

Divide the ogee between 2 and 5 in D E into equal spaces, as shown, and with C as center draw the dotted arcs shown. Below the normal profile draw any horizontal line, as *a b*, upon which drop the projections of the various points in the profile and place these projections in a horizontal position shown by *a′ b′*. At right angles to *a′ b′* from the various projections, drop vertical lines, which intersect by lines drawn at right angles to A B from previously intersected arcs drawn from the center C. Trace a line through points thus obtained, resulting in the modified profile for the curved molding, shown by *d e*. Between these two profiles, namely, the normal and modified, a miter joint can be effected. For the pattern for the lower return take the stretchout of D E and place it on any vertical lines, as F G. Draw the usual measuring lines, which intersect by vertical lines dropped from the divisions in the profile D E, as in a square miter. Then F G H J represents the pattern for the lower return. The distance from F to J is made as long as required.

Assuming that the curved molding is to be made by machine, and the blank is to be developed, which will be accomplished as follows: Draw a line through the extreme points of the modified profile, as shown by 2 6 and 1 7. Bisect the distance 1 2 and 6 7 and draw the averaged line *d e*, extending it until it meets the line drawn from the center point C, at right angles to A C, at L. Then L is the center with which to strike the pattern. Obtain the girth of the profile from 5 to 1 and place it on the line *d e* above 5, and also the girth from 5 to 7 and place it below 5, as shown. Using L as center with radii equal to L *e* and L *d*, draw the arcs *d i* and *e h*, making the blank as long as required, or twice the girth of the arc D A in elevation.

The miter cuts are not placed upon the blanks for circular moldings, but are trimmed after they are hammered up. So that this cut may have the proper projection, a small template is used to mark the miter on the curved mold, the pattern for which is obtained by placing the girth of that portion shown from 1 to 5 in the modified profile, at right angle to a line drawn tangent at D in elevation as D D°, as shown by D 5°. Through the small figures 1° to 5° at right angles to D 5° draw measuring lines, which intersect by lines drawn at right angles to D D° from the intersections 1 to 5 in the normal profile thus obtaining the cut 1° 5^{x}. Trace this cut, 1° 5^{x}, opposite the line 1° 5°, and obtain 1° 5^{v}. Then 5^{x} 1° 5^{v} is the right and left miter cut formed to correspond to the modified profile and is used in trimming the miters in the curved molding.

When the curved molding must be made by hand the various faces are stripped as shown in the diagram X Y and the ogee V developed the same as explained in connection with *d e* in the modified profile, and soldered in position at *n* and *o* in the diagram X Y.

RAKING MOLDINGS—VI

When a curved molding is to miter with a horizontal molding at other than a

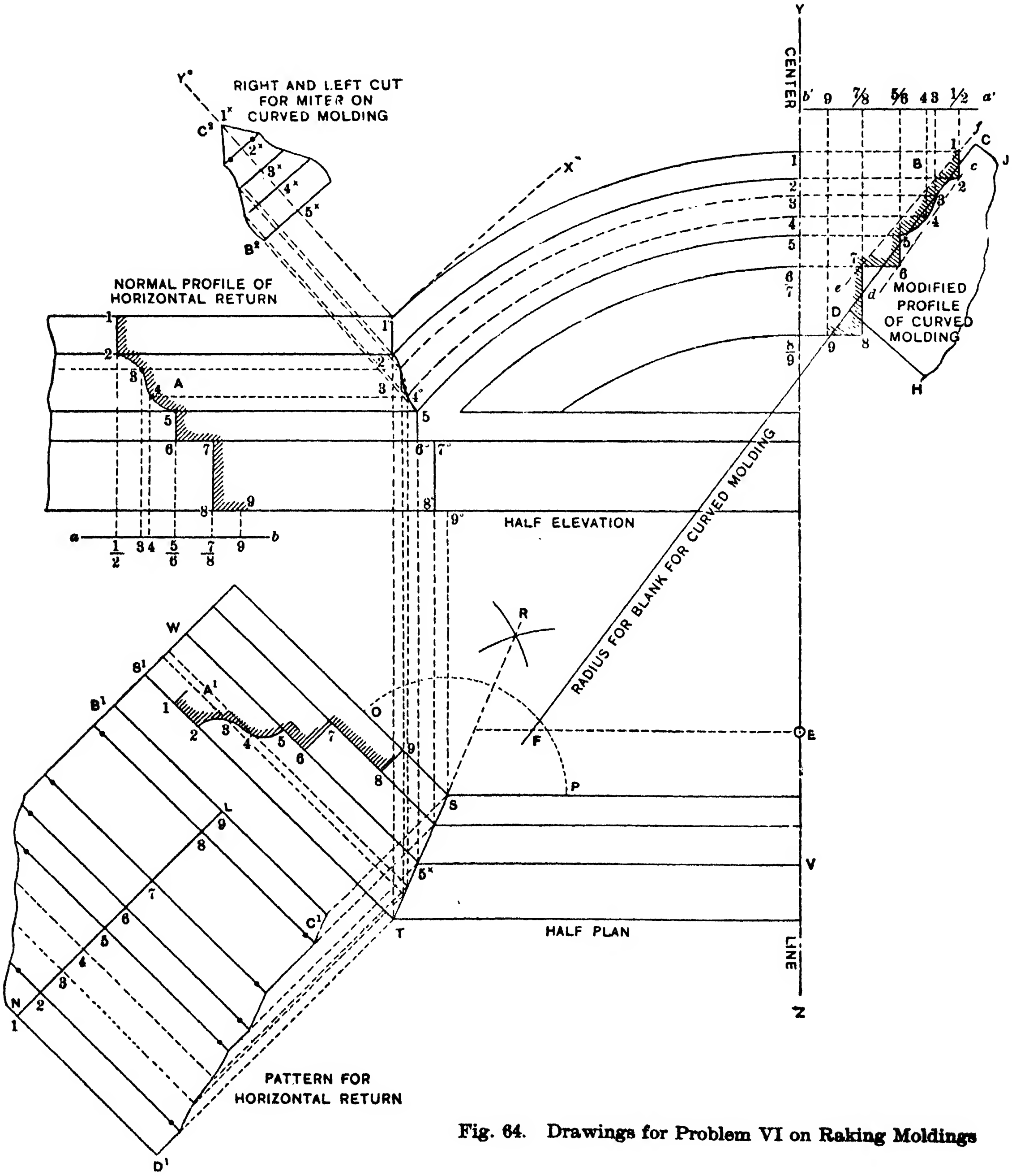


Fig. 64. Drawings for Problem VI on Raking Moldings

right angle in plan, the normal profile being placed in the horizontal molding, then the method to be employed is shown in Problem VI.

In Fig. 64 first draw the center line Y Z, and establish the width of the front elevation of the curved molding as shown by 5°. Drop the vertical line 5° 5^x, and establish the desired angle between the curved and horizontal mold as shown by V 5^x W in the half plan. From 5° in elevation, draw the horizontal line 5° $5_{,}$ upon which place the normal profile of the horizontal return as shown by A.

Divide the profile A into equal spaces, and draw horizontal lines as shown. Now take a tracing of the normal profile A, and place it in its proper position in plan as shown by A^1. Divide into similar divisions as in A. Through the divisions in A^1, draw lines parallel to 5^x W, and complete the half plan shown.

Bisect the angle O P by the miter line R S T. From the intersections on the miter line S T, erect vertical lines intersecting horizontal lines drawn from A in elevation, resulting in the miter line 1° to 9°. Establish the center point E on the center line Y Z, and describe arcs from the various divisions in the miter line in elevation 1° to 5°, intersecting the center line as shown, and complete the rest of the half elevation.

Obtain the projections of the normal profile A on the horizontal line *a b*, and place a duplicate of it in the position shown by a^1 b^1. Drop vertical lines from the various divisions on a^1 b^1, which intersect by lines drawn at right angles to Y Z from similar intersections obtained from the miter line 1° 5°. Trace a line through points thus obtained, and B will be the profile of the curved molding. Obtain the blank for the curved molding by drawing 2 6 and 1 7 in B. Then bisect 1 2 and 6 7 and average a line until it intersects the horizontal line from E at F. Then F is the center with which to strike the blank, partly shown by C D H J, C D being the girth of the molding 1 to 7 in B.

The pattern for the horizontal molding is obtained by placing the girth of A^1 in plan on L N drawn at right angles to S^1 T, drawing the usual measuring lines at right angles to L N, and intersecting them by lines drawn parallel to L N from similar numbered intersections on the miter line S T. Then B^1 C^1 D^1 is the pattern required.

For the pattern for the miter with which to trim the ends of the curved molding to miter with the horizontal returns, proceed as follows: Draw the tangent line 1° X in elevation. At right angles to it draw 1° Y°, upon which place the girth of the modified profile from 1 to 5. Draw the usual measuring lines, which intersect by lines drawn parallel to 1° Y° from similar intersections in the miter line 1° to 5°, resulting in the cut, shown by B^2, C^2. Trace the cut opposite the line 1° Y°, which completes the right and left miter cut for the curved molding.

RAKING MOLDINGS—VII

When a circular molding is to have a right angle return and the normal or given profile is placed to the curved molding, then the method to be employed is shown in the drawing herewith, Fig. 65. In this the one-half front elevation is shown.

In its propor position place the normal profile of the curved molding A. Divide this into equal spaces, and from the points determined draw lines at right angles to the center line in elevation, intersecting it as shown. With B as center draw the various arcs shown. Intersect the arcs by vertical lines drawn from the projections on $a' \ b'$ placed in its proper position, and which had previously been obtained from the normal profile A on $a \ b$. Trace a line through points thus obtained, and then will D be the modified profile for the horizontal return.

The girth of D is now taken and placed on the vertical line 1″ 10″, the usual measuring lines drawn and intersected by vertical lines dropped from similar numbered intersections in D, resulting in the miter cut or pattern for the horizontal return, shown by C D°. The depth from C to 1″ can be made the length desired. Thus it will be seen that the principle in this case is similar to that given in Problem V, with the exception that the normal or given profile is placed in the curved molding in Problem VII.

The blank for the curved molding made by machine is obtained by averaging a line through the profile A, between the two lines drawn from 1 to 8 and from 2 to 7, extending the averaged line until it meets the horizontal line drawn from the center point B at C°. The girth of the profile A from 1 to 8 is then obtained, and using C° as center the blank is struck as partly shown.

To obtain the miter cut with which to trim the ends of the curved molding, take the girth from 1 to 8 in A and place it at right angles to the tangent line 1′ X, as shown by 1′ Y. Draw the usual measuring lines parallel to 1′ X, and intersect them by lines drawn parallel to 1′ Y from similar numbered intersections in the profile D, resulting in the miter cut shown. Trace opposite the line 1′ Y and complete the pattern for a right and left cut.

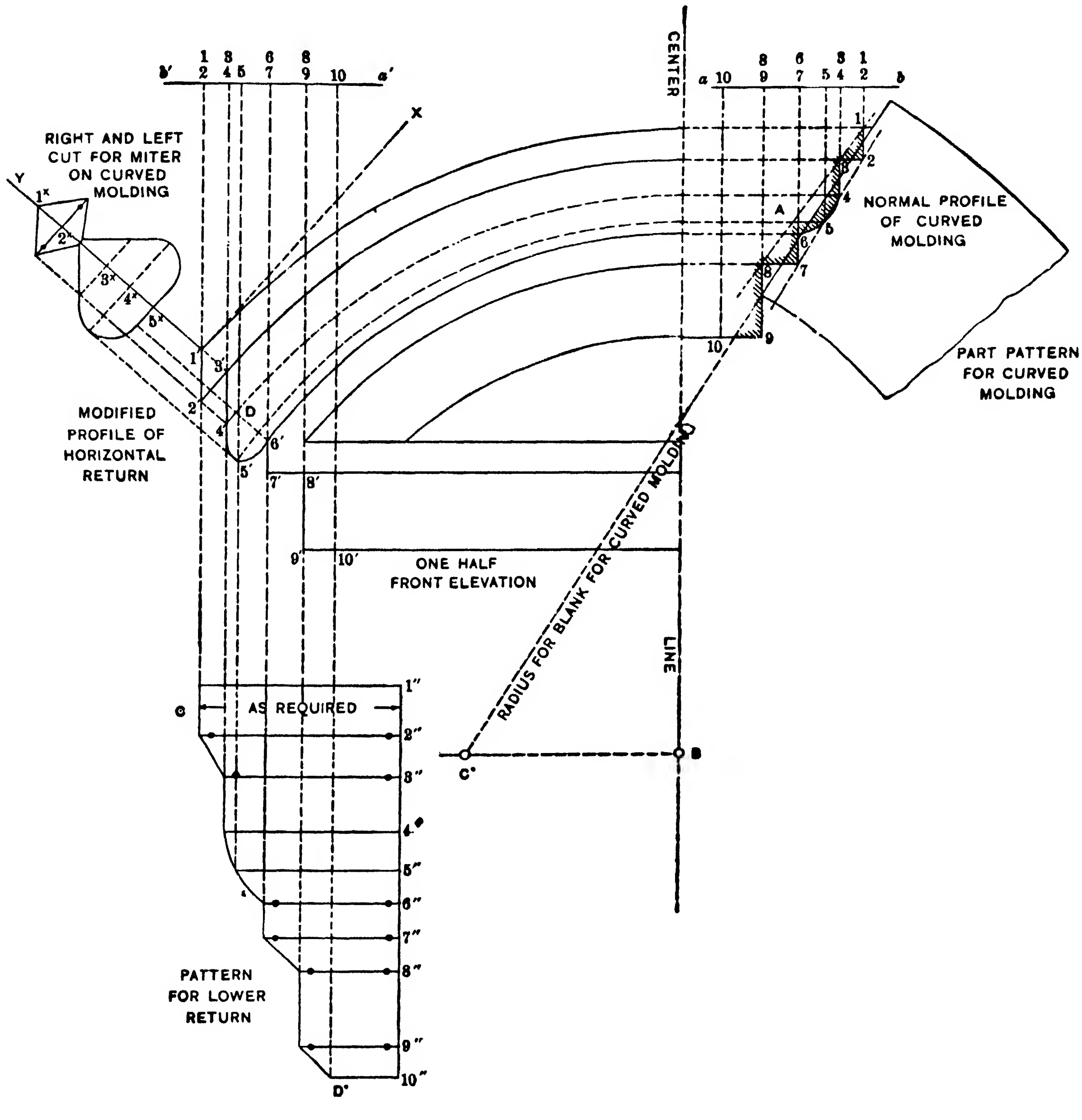


Fig 65. Drawing for Problem VII on Raking Moldings

RAKING MOLDINGS—VIII

In this problem it is shown how the patterns are obtained when the given profile is placed in the curved molding, which miters with a horizontal return at other than a right angle in plan. First, draw the half plan and elevation in their proper positions and place the normal or given profile A with its various divisions at right angles to the center line, as shown in Fig. 66. In its proper position in plan, place a tracing of the profile A with its various divisions as shown by A^1. Complete the plan J H G F E D and draw the miter line E H. With B as center, and radii equal to the divisions on the center line, obtained from the profile A, draw the various arcs, which intersect by vertical lines, erected from the points on the miter line H E in plan, and resulting in the miter line $1°$ to $10°$ in elevation. From the various points, $1°$ to $10°$, draw horizontal lines as shown. Obtain the projections from A onto *a b*, and place on the horizontal line a^1 b^1, from which drop vertical lines intersecting those obtained from $1°$ to $10°$, and resulting in the modified profile for the horizontal return indicated by B from 1^1 to 10^1. Obtain the girth of B and place it on a line drawn at right angles to F E in plan, as M L. Draw the usual measuring lines, which intersect by lines drawn parallel to M L from the various intersections on the miter line H E. Then R S T represents the pattern for the horizontal return.

The miter cut for trimming the curved molding is shown at Y, which is obtained by taking the girth of A from 1 to 6 and placing it on the line W $1°$ drawn at right angles to $1°$ X and the pattern obtained in the usual manner. The center for obtaining the pattern for the curved molding is shown at C, the averaged line being drawn between 3 8 and 2 7.

In this problem the principle is similar to that shown in Problem VI, except that in Problem VIII the given profile is placed in the circular molding.

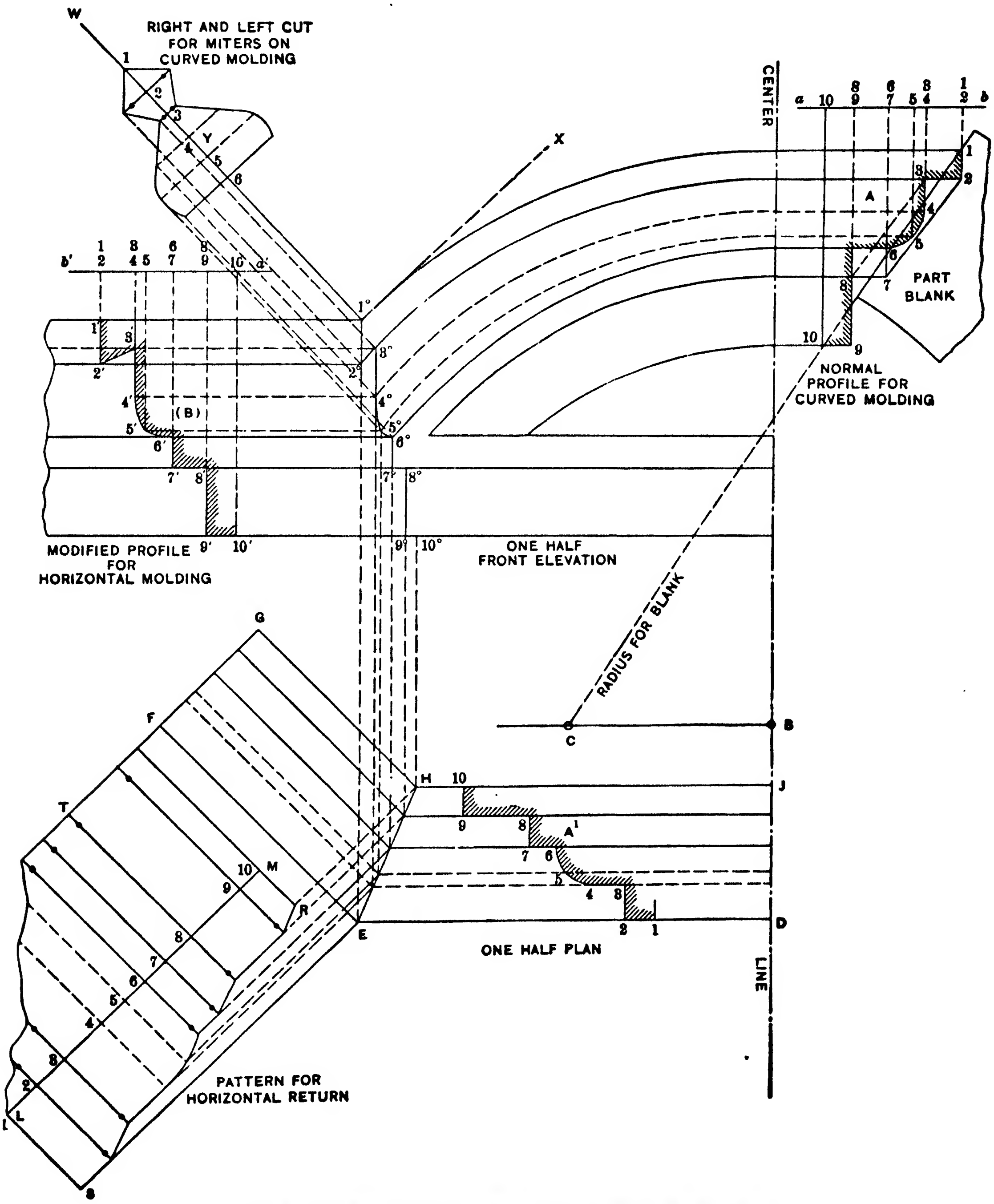


Fig. 66. Drawing for Problem VIII on Raking Moldings

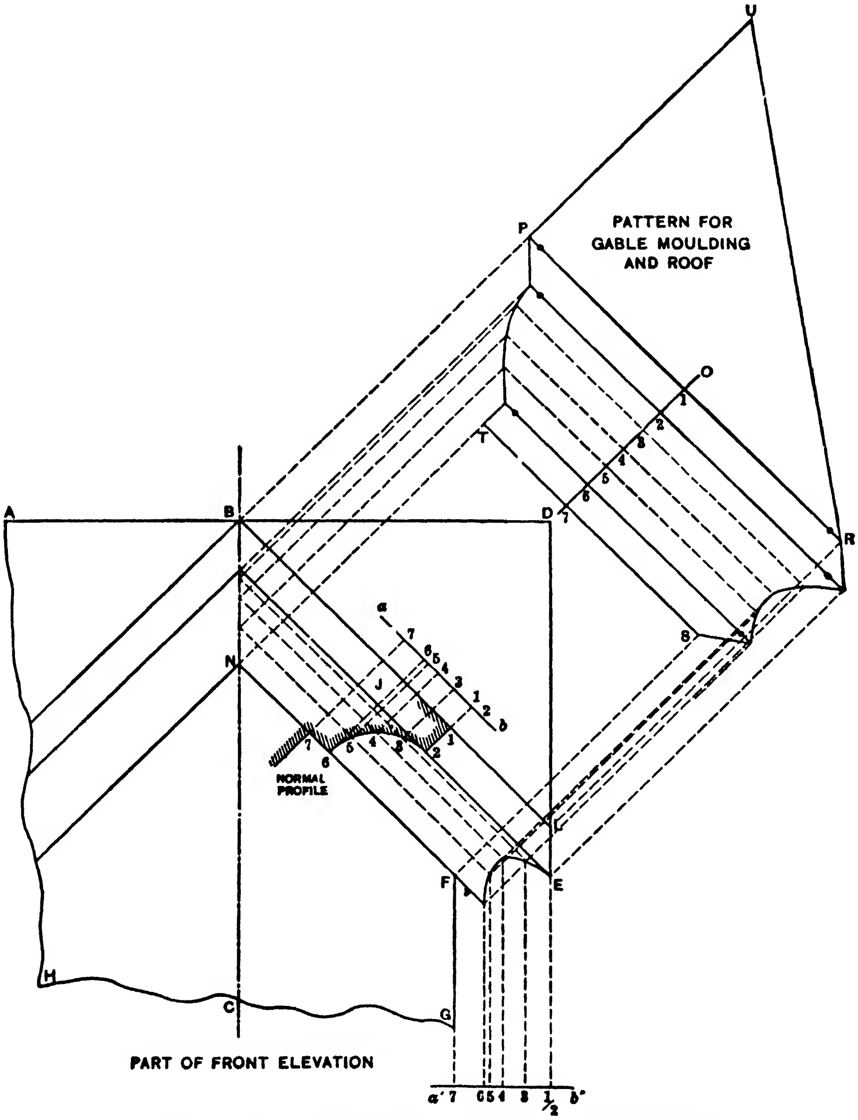


Fig. 67. Drawing for Problem IX on Raking Moldings

RAKING MOLDINGS—IX

When four gables are to be joined together at right angles in plan, each side being similar in width, then the method to be employed is shown in Problem IX. A part front elevation is shown by A D E G H, Fig. 67. The one-half elevation only is required. After the rake N F has been established place the normal or given profile J in its proper position, as shown, and divide it into equal spaces, as from 1 to 7. Parallel to the rake N F draw any line, as *a b*, upon which obtain the projections of the various points in the profile J. Take a tracing of *a b* and place it in a horizontal position, as shown by *a′ b′*, being careful to have the point 7 come in line with F G. From the various projections on *a′ b′* erect vertical lines, which intersect by lines drawn parallel to the rake from the various intersections in the profile J, resulting in the miter line L E F.

Having established the miter line L E F and knowing the line of joint, N B, the pattern is developed as follows: At right angles to B L draw any line, as D O, upon which place the stretchout of the profile J, as shown. At right angles to D O through the various points on same, draw lines which intersect by lines drawn at right angles to B L from similar points in the miter line L E F and line of joint N B, resulting in the pattern for the gable molding, P T S R. If the roof shown by B D L in elevation is to be joined to the molding in one piece, then, at right angles to R P in the pattern, draw the line P U, equal in length to B D in elevation, and draw a line from U to R in the pattern. U P T S R U is then the full pattern, of which eight are required. The above principle is applicable to any shaped mold.

RAKING MOLDINGS—X

When four gables are to be joined together with alternate wide and narrow sides, as shown by Fig. 68 in the reduced plan by A and B, then the principle to be employed is shown in Problem X. In this case the normal or given profile will be placed in the wide side and the modification made in the narrow side. Should, however, the given profile be placed in the narrow side, the modified profile in the wide side would then be obtained in precisely the same manner as that which will follow:

First, draw the center line I F of the wide side, and draw the one-half elevation of the shaft with its proper rake as shown by C D E F. Place the normal profile G in its proper position, which divided into equal spaces, as shown, from 1 to 7. Through these draw lines parallel to C D indefinitely. Obtain the projections of the profile G upon the line *a b*, drawn parallel to I H, and transfer these projections upon the horizontal line *a′ b′*, as shown, being careful that the point 7 will be in line with D E. From the various projections on *a′ b′* erect the vertical lines intersecting those previously drawn parallel to I H, giving the miter line H, 2, 6, D.

Take a tracing of H, 2, 6, D and place it, as shown, from 1′ to 7′, on horizontal lines drawn from H D, as shown. From 7′ place the half horizontal distance of the narrow side of shaft 7′ *f* and draw the vertical center line through *f*, as shown by L K. From I, in the wide side, draw the horizontal line I K, intersecting the center line L K at K. Draw a line from K to 1′, and parallel to this line, from the various intersections 1′ to 7′, draw lines intersecting the center line K L, as shown. Take a tracing of the projections on *a b* and place them parallel to 1′ K as shown by *a″ b″*. From the points on *a″ b″*, at right angles to 1′ K, draw lines intersecting lines previously drawn, as shown by the intersections 1 to 7 on R S; through these points at right angles to narrow side. Complete the ridge lines I J H in the elevation of the wide side and K P 1′ in the elevation in the elevation of the narrow side as shown.

For the pattern for the wide side proceed as follows: At right angles to I H draw any line as R S, upon which place the girth of the normal profile G, as shown from 1 on 7 on R S. Through these points at right angles to R S draw the usual measuring lines, which intersect by lines drawn from similar numbers on the miter line I C and H 2 D, at right angles to I H, and resulting in the pattern V U T P^1. If the roof is to be added to the pattern, then take the distance from P to K in the narrow side and place it at right angles to T P^1 in the pattern, as shown by P^1 K^1, and draw a line from K^1 to T. Then K^1 V U T is the full pattern, of which four will be required.

For the pattern for the narrow side, take the girth of the modified profile O and place it on the line X Y, drawn at right angles to 1′ K, as shown from 1° to 7° on X Y. Draw the usual measuring lines, which intersect by lines drawn at right angles to 1′ K from similar intersections on the miter line K N and 1′ 7′ and resulting in the pattern Y Z and J^1. Then will 1^1 Y Z and J^1 I^1 be the full pattern for the narrow side, of which four will be required. Where the roofs are of such size that they can not be joined direct to the molding, then laps must be allowed to the patterns for the moldings, so that the roofs can be locked to them.

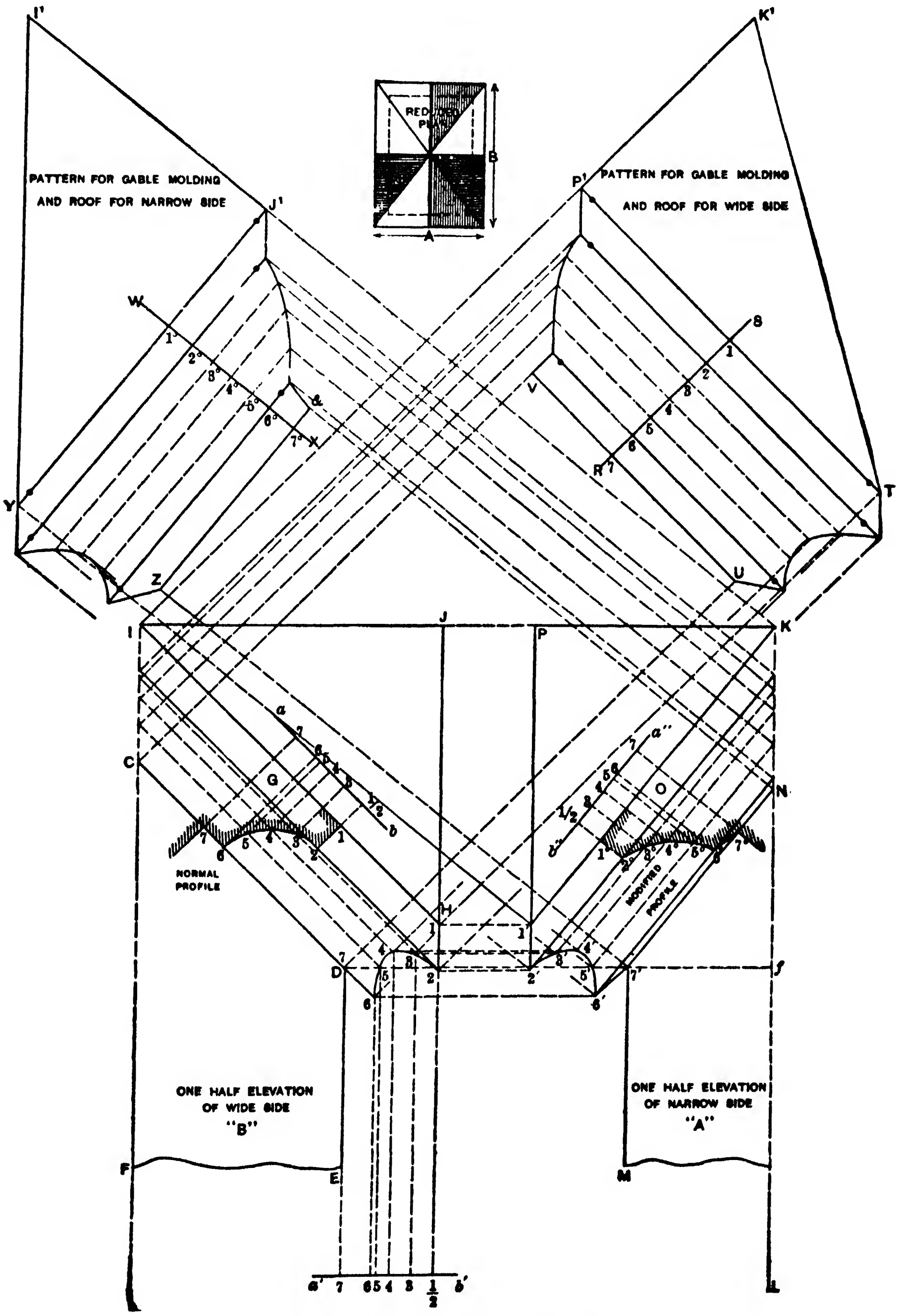


Fig. 68. Drawings for Problem X on Raking Moldings

RAKING MOLDING—XI

In Problem XI is shown how the patterns are developed when eight gables are to be joined together at the angles of an octagon or 135 degrees. The principles here shown are applicable to any angle, providing, however, that the angles are equal and that each side has the same width.

In Fig. 69 first draw the center line A B, and with C on that line as center and with radius equal to the half width of the shaft as C D, draw the quadrant D E. Now complete the one-quarter plan of the shaft as shown by D G F 7′ E, as shown by the dotted line. Place the normal profile H on the line of the shaft as shown, and divide same into equal spaces shown from 1 to 7. Draw the valley or miter lines C 7′, C G, also the ridge line C F, extending same to meet the projection of the molding H. Through the various divisions in H draw the lines parallel to E 7′, intersecting the miter line from 1′ to 7′ as shown. From 7′, in plan, erect the vertical line 7′ 7°, and draw the desired rake 7° J. Then J K L 7° will represent the one-half elevation of one side of shaft, all that is necessary in the development of the pattern.

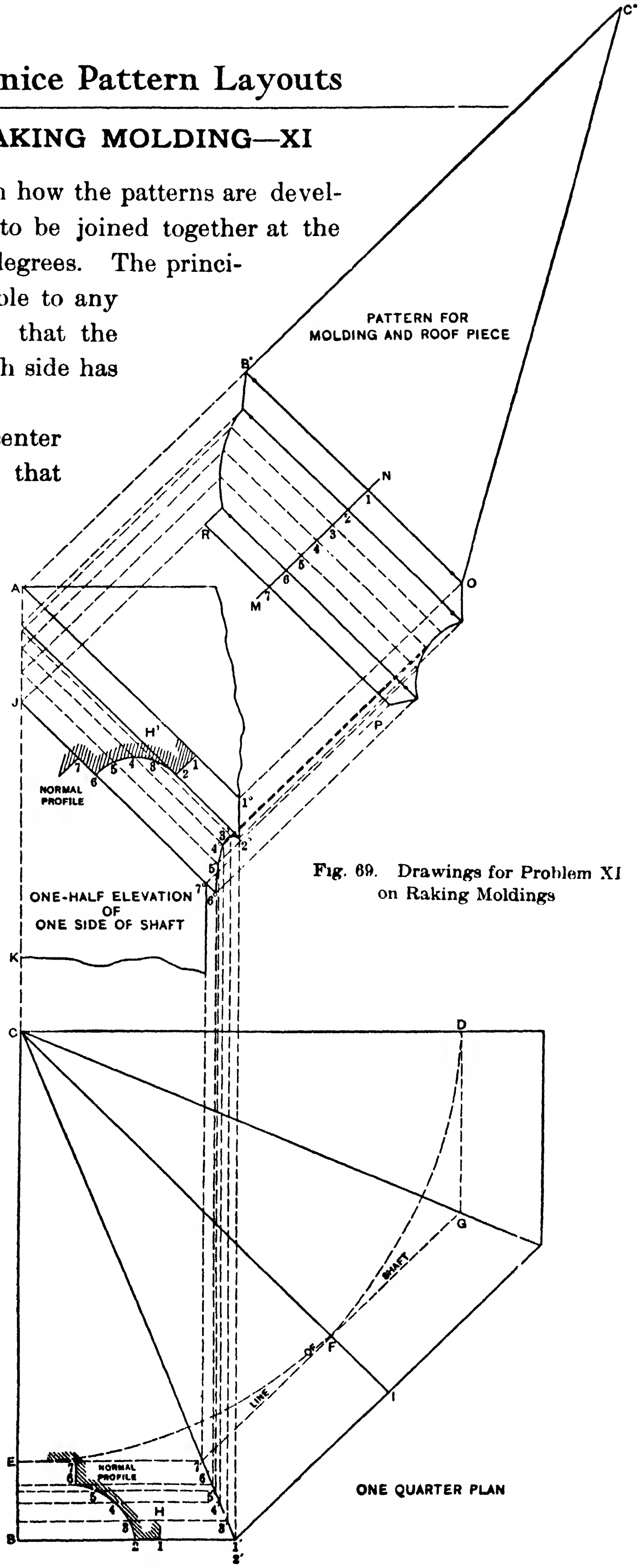


Fig. 69. Drawings for Problem XI on Raking Moldings

Take a tracing of the normal profile H with the various intersections on same, and place it as shown by H^1. Through the points in H^1 parallel to J 7° draw lines, which intersect by vertical lines drawn from similar numbered points on the miter line in plan, parallel to the center line B A, and resulting in the miter line in elevation shown from 1° to 7°.

Having obtained this miter line, the pattern is obtained as follows: At right angles to A 1° draw the line M N, upon which place the girth of the profile H or H^1 as shown from 1 to 7 on M N. Draw the usual measuring lines, which intersect by lines drawn at right angles to A 1° from similar points on the miter lines A J and 1° to 7°. Trace a line through points thus obtained, then will O P R B° be the pattern for the molding. If the roof piece is to be attached to same, then take the length of the ridge line B C in plan, and lay it off at right angles to B° O in the pattern as shown from B° to C°, and draw the valley line C° O. Then C° R P C° is the full pattern, of which 16 will be required.

RAKING MOLDINGS—XII

When gables are to be joined together having alternate wide and narrow sides, and the angles are not right angles, then the principles shown in problem XII are applicable to any angle or width of alternate sides. Let A B C D E, in Fig. 70, represent the one-quarter plan of shaft having alternate wide and narrow sides. Place the normal profile F in its proper position and complete the plan view of the molding, as shown by G H I J K. Draw the miter or joint lines of the molding, as shown by D H and J C, and the valley lines of the roof H A and J A, and the ridge lines A K, A I and A G.

Divide the normal profile F into equal spaces and draw lines parallel to E D until they intersect the miter line D H, as shown. From D erect the vertical line D 7°, and draw the desired pitch 7° M. Then M N O 7° represents the one-half elevation of wide side of shaft.

Place the normal profile F in the position shown by F^1, and divide F^1 into the same number of spaces as F. It should be understood that, while the normal profile is placed in the wide side, it could just as well be placed in the narrow side, and then proceed as follows: From the various intersections in F^1 parallel to L 1° draw lines, which intersect by vertical lines erected from intersections on the miter line D H in plan, and resulting in the miter line shown from 1° to 7° in elevation for wide side.

For the one-half elevation of the narrow side draw any vertical line, as P R, and from R set off the horizontal distance R S equal to one-half of the narrow side, C D, in plan. From S draw the vertical line shown, which intersect by a horizontal line drawn from 7° in wide side at 7ᵛ in the narrow side. Take a tracing of the miter line 1° 7° and place it as shown by 1ᵛ 7ᵛ, being careful that 7° is placed directly on 7ᵛ, and that 1ᵛ 2ᵛ is in a vertical position, as shown by the dotted lines drawn from 1° to 7°.

From L in the elevation of the wide side draw a horizontal line, intersecting R P in narrow side at P. Draw a line from P to 1ᵛ, and parallel to this line, from the various intersections in 1ᵛ 7ᵛ, draw lines in-

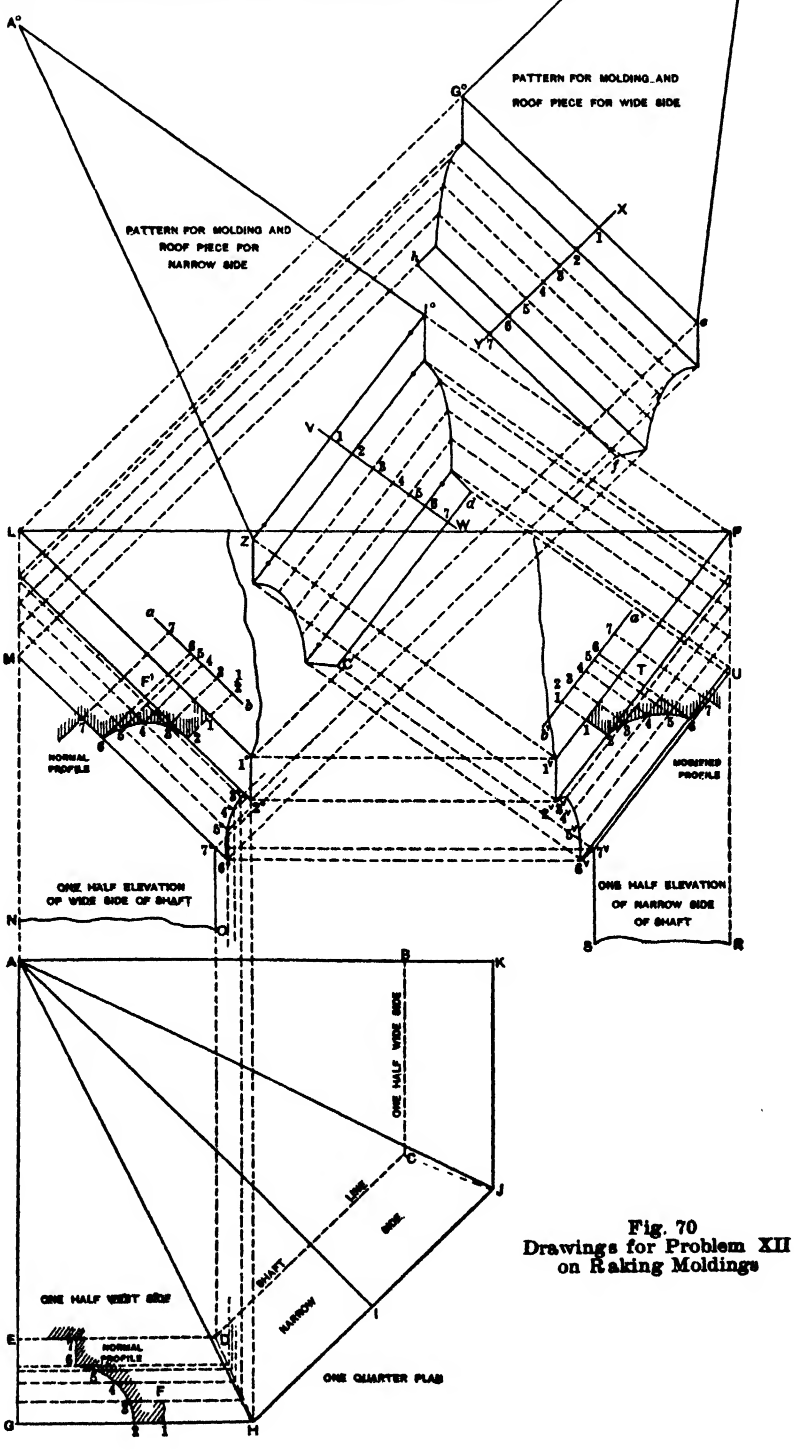


Fig. 70
Drawings for Problem XII
on Raking Moldings

tersecting the center line P R, as shown. Now obtain the projections of the normal profile F^1 on the line *a b*, drawn parallel to L 1°, as shown from 1 to 7 on *a b*. Take a tracing of *a b* and place it parallel to P 1^v, as shown by a^1 b^1, from which points at right angle to b^1 a^1 draw lines intersecting lines previously drawn from the miter line 1^v 7^v. Trace a line through points thus obtained, then will T be the modified profile for the molding on the narrow side.

For the pattern for the narrow side take the stretchout of the modified profile T and place it on the line V W, drawn at right angles to 1^v P; draw the usual measuring lines, which intersect by lines drawn at right angles to P 1^v, from intersections on the miter lines 1^v 7^v and P U, and resulting in the pattern for the molding shown by Z I° *d c*.

If the roof is to be attached to this mold, then take the distance of the ridge line A I in the narrow side in plan and place it at right angles to Z I°, as shown from I° to A°, and draw a line from A° to Z. Then A° *c d* is the full pattern, of which eight will be required.

For the pattern for the wide side take the girth of the normal profile F^1 and place it at right angles to L 1°, as shown by X Y. Draw the usual measuring lines at right angles to X Y, which intersect by lines drawn at right angles to L 1°, from intersections on L M and 1° 7°. Then *e f h* G° is the desired pattern. At right angles to *e* G° draw the line G° A^x equal in length to the ridge line G A in the wide side in plan. Draw a line from A^x to *e* in the pattern. Then will A^x *h f* be the complete pattern for the roof and molding for the wide side, of which eight will be required.

RAKING INSIDE MITER BETWEEN INCLINED ARMS

The method of obtaining the patterns for raking moldings, such as the ones shown at A and B of the plan and elevation, in Fig. 71, is as follows: From this it appears that portions of the front wall of a building, as seen at B B of the plan, are placed obliquely to the main front A A, both portions of either half of the front terminating at the eaves of a roof of uniform pitch throughout, as shown by A A and B B of the elevation. The difficult part of the problem is to cut the miter between the two arms A and B of the cornice as well as the miter at its upper end, that at the lower end being a simple butt miter.

In Fig. 72 is shown an enlarged plan and elevation giving all the details of the molding, in which the profile and the several miter lines have been brought close together for convenience in performing the work. The elevation of both arms of

the molding is shown by A B C D, the portion E B C F of the elevation of which I K L J is the plan only appearing in true elevation; while A E F D is an oblique elevation of the upper arm, as shown by G I J H of the plan. The normal profile of the cornice is shown at M of the elevation, from the points of which lines are drawn parallel to the pitch of the roof A B, and terminated at the top and ends by the sides of the piers against which the cornice abuts. At N of the plan the normal profile is also shown correctly placed with reference to the lines of that view. Through the point of extreme projection of the profile in plan draw the line J L; also draw H J parallel to G I at a distance from it equal to K L, the projection of the molding. From the intersection J of these two lines draw J I; then will J I be the correct miter line in plan between the two arms of the molding; or, in other words, the position of a vertical plane against the opposite sides of which the two arms of the molding must meet at different angles, forming the miter at E F of the elevation.

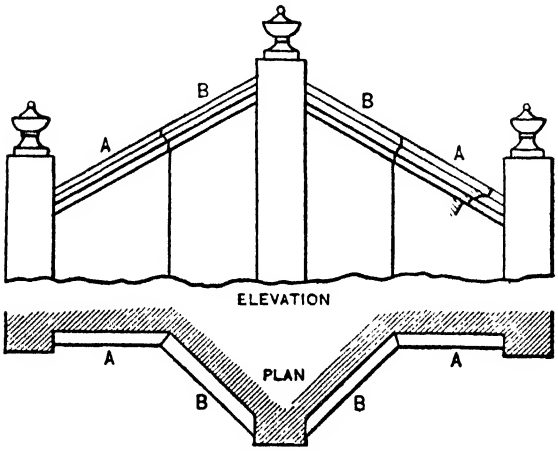


Fig. 71. Raking Inside Miter Between Inclined Arm

As the miter cannot be cut from the plan for the reason that the arms are inclined, the first requisite is to obtain a correct elevation of the miter at E F. To accomplish this first divide the curved portions of the two profiles M and N into the same number of equal spaces, as shown by the small figures, and from all the points of the profile N carry lines parallel to I K, cutting the miter line I J. From the several points in the profile M carry lines parallel to E B to the right, cutting B C, the side of the pier against which the cornice is required to miter at its lower end; also carry them toward E F indefinitely and intersect them with lines drawn vertically from points of corresponding number previously obtained on I J. A line traced through the points of intersection between E and F will give the required miter line in elevation, as shown.

To lay out the pattern for this arm first set off the stretchout of M upon any line, as O P, drawn at right angles to E B, as shown by the small figures 1 to 10. Through the several points on O P draw the measuring lines, as shown, parallel to E B, which intersect at the right by lines drawn parallel to O P from the points of corresponding number on B C. A line traced through the points of intersection, as shown from B^1 to C^1, will give the required miter at B C. Now from the points

of intersection previously obtained between E and F carry lines parallel to O P, cutting measuring lines of corresponding number at their left, when a line traced through the points of intersection, as shown from E' to F', will give the required miter cut at E F of the elevation.

Since that portion of the wall between the lines E S and A T of the elevation

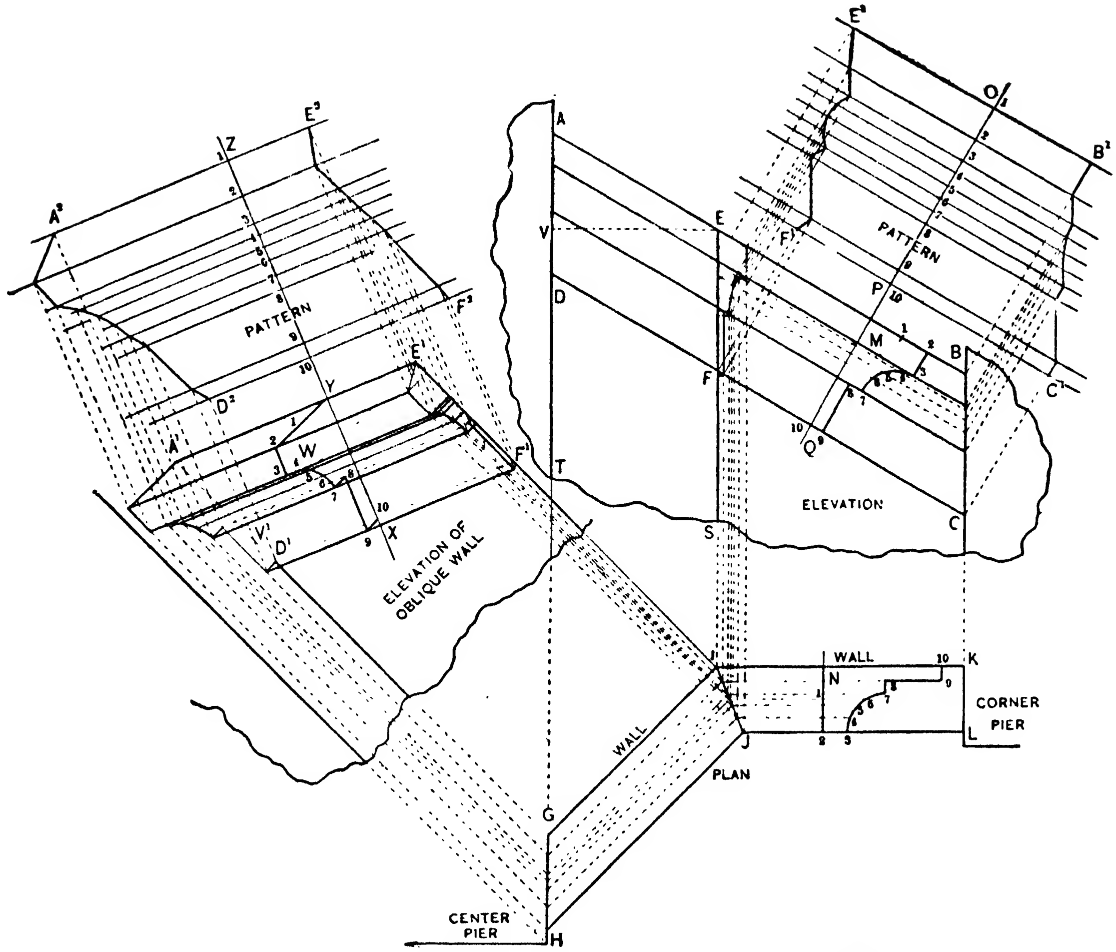


Fig. 72. Method of Obtaining the Patterns for Both Arms of the Miter.

stands obliquely to the other portion, as shown by G I of the plan, it is evident, as intimated above, that the angle D A E does not give the correct pitch or rake of this arm of the molding, for the reason that while A V gives the correct hight of the point A above the point E, the correct horizontal distance between those points is not V E, but is equal to G I. It will be necessary, therefore, to construct a tri-

angle the equivalent of A E V, but correct in all its dimensions. The best method of procedure then is to project an oblique elevation of the wall and cornice H G I J of the plan, as shown at the left in Fig. 72. Therefore from points G and I first erect the two lines I E^1 and G A^1 at right angles to G I, representing the perpendicular lines of the wall. Upon I E^1 assume any point, as E^1, the equivalent of the point E of the normal elevation, and from E^1 draw the horizontal line E^1 V^1, giving the true length of E V. Make V^1 A^1 equal to V A, and draw A^1 E^1; then will A^1 E^1 be the correct pitch of the arm shown by G H J I of the plan.

Since the miter line at E F of the elevation has been established, and since the arm at its left lies at a different angle to the perpendicular E S than the arm at the right, it is evident that the profile of the left arm of the miter must be so changed or raked that lines from all of its points shall meet lines from corresponding points of the normal profile M upon E F. To accomplish this it will first be necessary to place the miter line E F in its correct position in the oblique elevation. From an inspection of the plan it is evident that when the miter at I J is viewed at right angles to G I it will appear turned as much to the left as it appears turned to the right in the normal elevation, or when viewed at right angles to I K. Therefore the miter line as it appears at E F may be traced and transferred in a reversed position to the oblique elevation; or it may be obtained in the following manner: Carry short lines from each of the points by which it was originally obtained horizontally to the vertical line E F, and transfer the points thus found to E^1 F^1 of the oblique elevation, and draw horizontal lines from each to the left, which intersect by lines drawn perpendicular to G I from points of corresponding number on I J, all as shown. Now from each of the points in the miter line E^1 F^1, just obtained, draw lines parallel to the line of rake E^1 A^1 and continue them indefinitely beyond A^1 V^1. To obtain the profile of the raked molding draw any line, as X Y, at right angles across those just drawn, and upon each line set off from X Y the projection of the corresponding points in the normal profile M, as measured from P Q on lines parallel to E B; then will the profile W thus obtained be the correct profile of the left arm of the miter. To obtain the miter at the left or upper end of this arm, first carry lines from each of the points on I J of the plan parallel to I G till they intersect the side of the center pier at G H, and from the points thus obtained erect lines at right angles to G I, intersecting those of corresponding number previously drawn from E^1 F^1. A line traced through the points of intersection, as shown from A^1 to D^1, will give the required miter line.

To lay out the pattern of this arm of the molding, first set off the stretchout of the profile W on any line, as Y Z, drawn at right angles to A^1 E^1, and through the

points of the same draw the usual measuring lines parallel to $A^1 E^1$. It may be here noted that the spaces upon the curved portion of the profile W must be measured from point to point as they exist, as by the process of raking they are necessarily unequal. From each of the points in the two miter lines $A^1 D^1$ and $E^1 F^1$ carry lines parallel to Y Z till they intersect with measuring lines of corresponding number. Lines traced through the points of intersection, as shown at $A^2 D^2$ and $E^2 F^2$, will complete this pattern.

It will be understood that the correct lengths of $A^1 E^1$ and E B of Fig. 72 and their respective patterns are not given in the diagram, and that in practice the miter cuts at the two ends of either of the patterns given must be separated to the required dimensions or perhaps made into separate patterns.

If it is immaterial just what appearance the miter has, then the molding profile need not be raked, inasmuch as the two arms A and B of Fig. 72 lie in one plane; that is, the roof being of uniform pitch. In this case the miter E F will be perpendicular to the line of the roof A E B, of Fig. 72; requiring no change of profile for either arm. Then too, the miter cut will be the same for both arms.

PATTERN FOR RETURN IN GABLE MOLDING

Undoubtedly there was need for a solution of this decidedly interesting problem, the following was prepared and here reprinted. Therefore to cut the patterns for the moldings from R to S shown in Fig. 73, where R S S^1 R^1 is a reduced reproduction of the sketch, X showing the section on the lines A B. While all patterns are asked for, from R to S, the patterns are only shown for those pieces adjacent to the miters C, E and F of Fig. 74. The miter A is obtained the same as any ordinary gable miter, the miter B is a square outside miter, and the miter C is an inside face miter. The pattern for the miter T of Fig. 73 is obtained the same as in a raking molding with a square horizontal return. The method of obtaining the patterns for the cuts F and E of Fig. 74 are shown in Fig. 75, where D E F G H I J K L M is a reproduction of the front elevation of similar parts in Fig. 73, the cut against the leader head being omitted in Fig. 75, and P R S T U V W Q is the side elevation of the same. As A in the front elevation is the given profile for

the raking molding throughout, also for the horizontal molding F E in front view and the return and vertical molding P R S in side view, it follows that a change of profile must be obtained for the horizontal return S T N V in side view to permit of perfect miters at F and E of Fig. 74.

To obtain the change of profile shown at B in front view, Fig. 75, proceed as follows: Divide the curved portion of the profile A into equal spaces, as shown by the small figures 1 to 8. Construct a duplicate of the true profile at A^1, which also divide into similar spaces as profile A. Now, parallel to H G and from the small figures in the profile A^1, draw lines, which intersect with those of similar numbers drawn from the small figures in the profile A at right angles to F E. A line traced through the points of intersection thus obtained, as shown by the small figures 1^1 to 8^1, will be the profile for the horizontal molding shown in side view by T S V N.

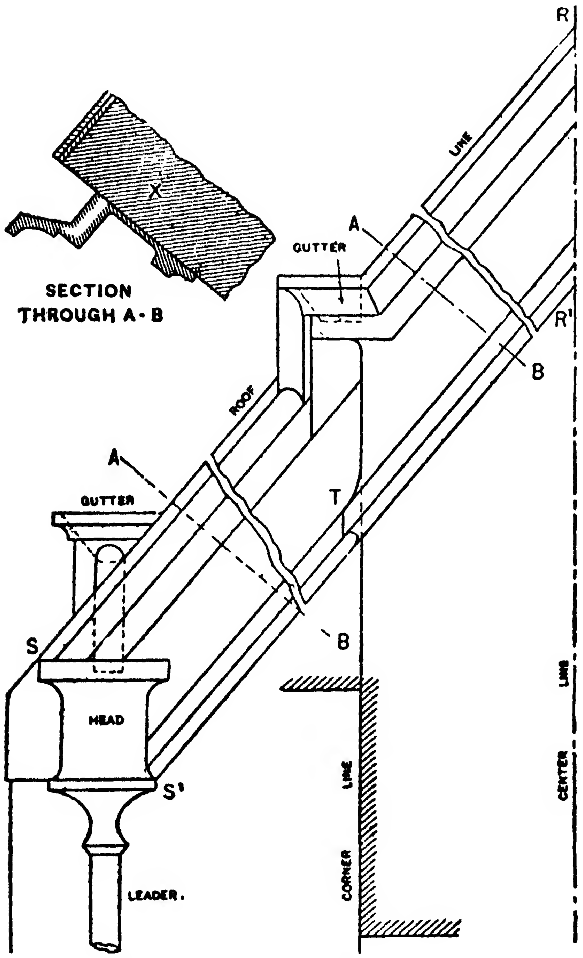


Fig. 78. Outline of Problem

Before obtaining the patterns for the vertical and horizontal moldings shown by R S T N V W it will be necessary to obtain the miter lines O and N in side view, for which proceed as follows: From the intersections in the profile B in front draw lines indefinitely at right angles to F G, as shown. Now take a tracing of the profile A and place it as shown in its proper position in side view by A^2. From the intersections on same and parallel to the lines of the molding draw lines, which intersect with the horizontal lines of similar numbers previously drawn from the profile B. A line traced through the intersections thus obtained, as shown from 1 to 8 in miter line N, will be the desired miter line between the raking and horizontal moldings. As the angle V W Q in side view is a right angle, then from the profile A carry lines parallel to P R until they intersect the miter line R W; then from the intersections on R W and parallel to R S drop lines intersecting the horizontal lines of similar numbers drawn from the profile B. A line traced through

intersections thus obtained, as shown at O, will be the miter line between the horizontal and vertical moldings of different profiles.

Having thus obtained the miter lines for the patterns proceed as follows: As the space does not allow obtaining the patterns direct from the views, each pattern is developed, as shown in Figs. 76, 77 and 78, by measurements instead of by projection, as usual. For the pattern for the vertical molding shown by R S V W in side view, Fig. 75, draw any horizontal line, as S^1 W^1 in Fig. 76, upon which place the stretchout of the profile A of Fig. 75, as shown by the small figures 1 to 8. At right angles to S^1 W^1 draw lines through the small figures indefinitely. Now, measuring in every instance from the line S W in side view, Fig. 75, take the

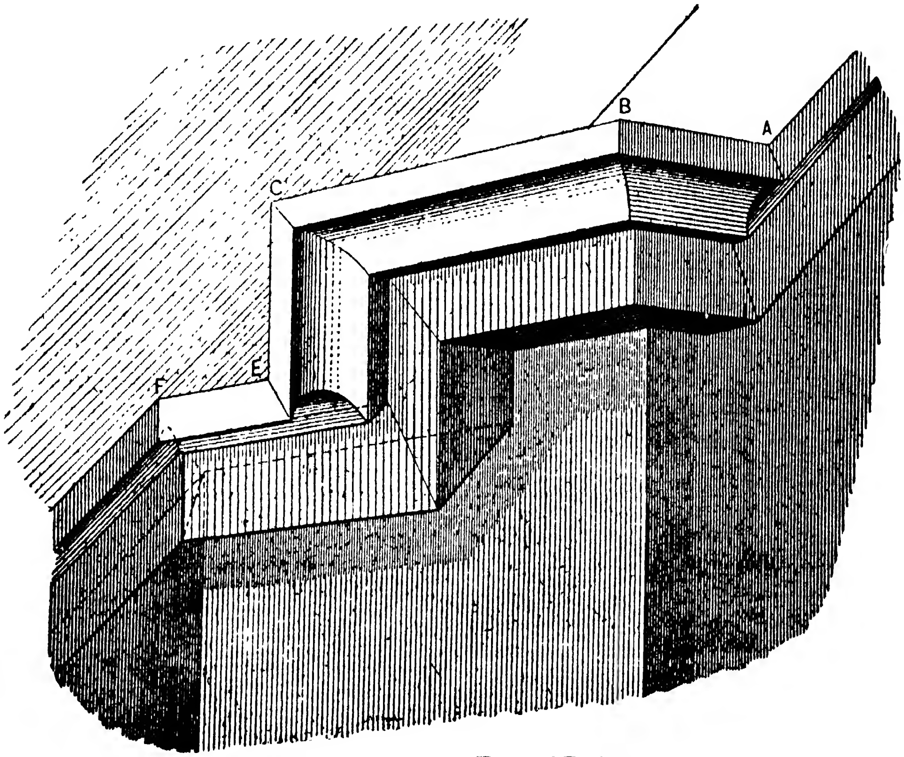
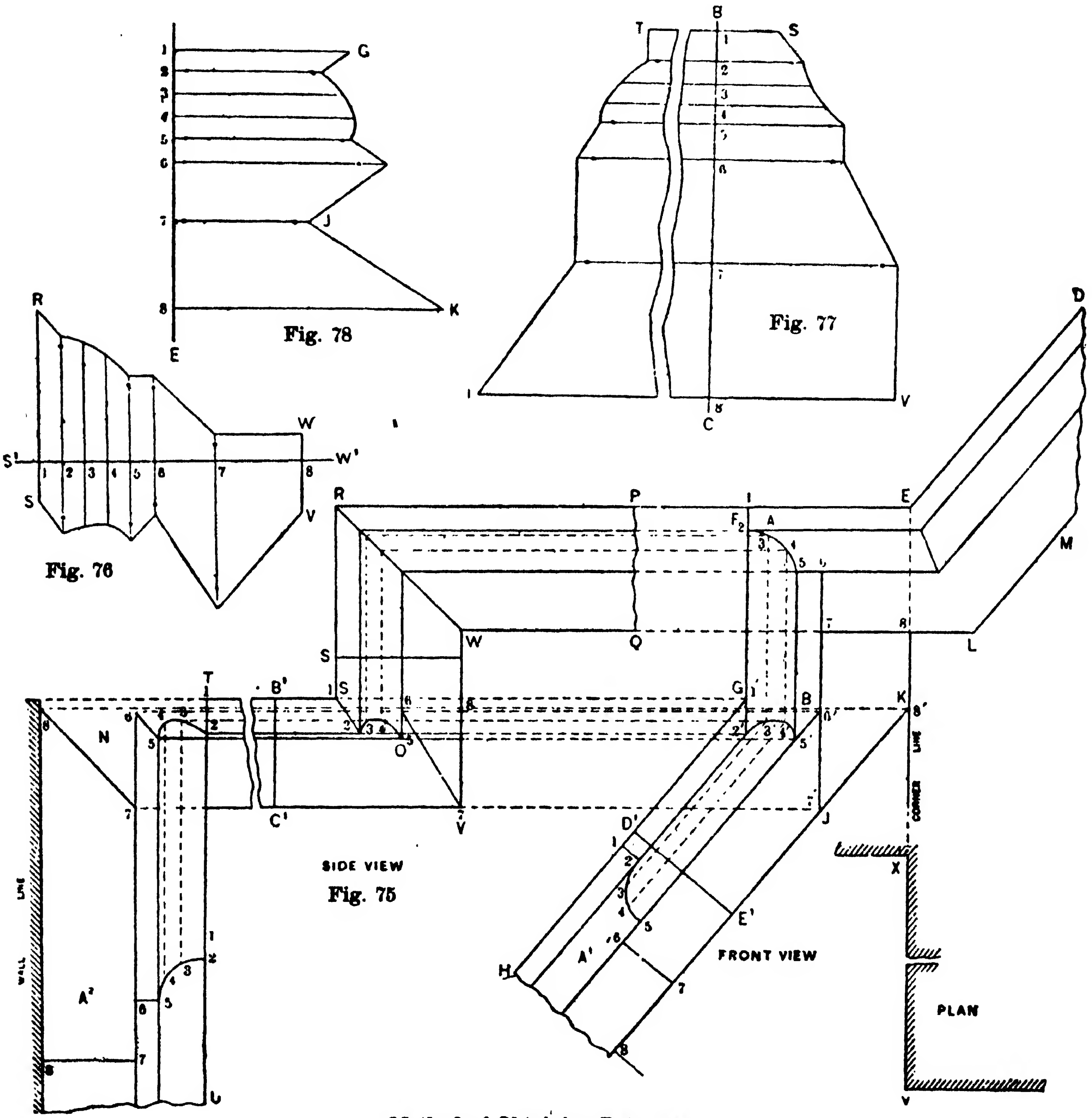


Fig. 74. Perspective View of Problem

distances on each of the lines to points in the miter line O from 1 to 8 and transfer them to lines of similar numbers in Fig. 76, measuring from S^1 W^1. In the same manner measure in every instance from S W in Fig. 75 to the miter line R W and carry these distances to lines of similar numbers in Fig. 76, measuring from S^1 W^1. Then a line traced through points thus obtained, as shown by R W and S V, will be the pattern for the vertical molding shown by R S V W of Fig. 75.

For the pattern for the horizontal molding shown by T S V N proceed in the same manner. Draw any vertical line, as B C in Fig. 77, upon which place the

stretchout of the profile B in front view, Fig. 75, as shown by the small figures 1 to 8. At right angles to B C and through the small figures draw lines indefinitely, as shown. Now, measuring in every instance from the line B^1 C^1 in Fig. 75 right and left to points of intersection in the miter lines O and N, carry these distances to lines



Method of Obtaining Patterns

of similar numbers in Fig. 77, measuring right and left from the line B C. A line traced through points thus obtained, as shown by T S V N, will be the pattern for the horizontal molding shown in side view, Fig. 75, by T S V N. In similar manner obtain the pattern for the raking molding in front view, Fig. 75. Draw any

vertical line as D E in Fig. 78, upon which place the stretchout of the profile A or A^1 of Fig. 75, as shown by spaces 1 to 8. At right angles to D E draw lines indefinitely, as shown. Now, measuring in every instance from the line D^1 E^1 in Fig. 75 to points of intersection in the profile B, carry these distances on lines of similar number in Fig. 78, measuring from the line D E. Trace a line through intersections, as shown, when D G K E will be the pattern for the raking molding shown by D^1 G K E^1 of Fig. 75.

PATTERN FOR A RAKING BRACKET

This Problem has one or two different features, and as it is a design of bracket of frequent occurrence, it is here presented.

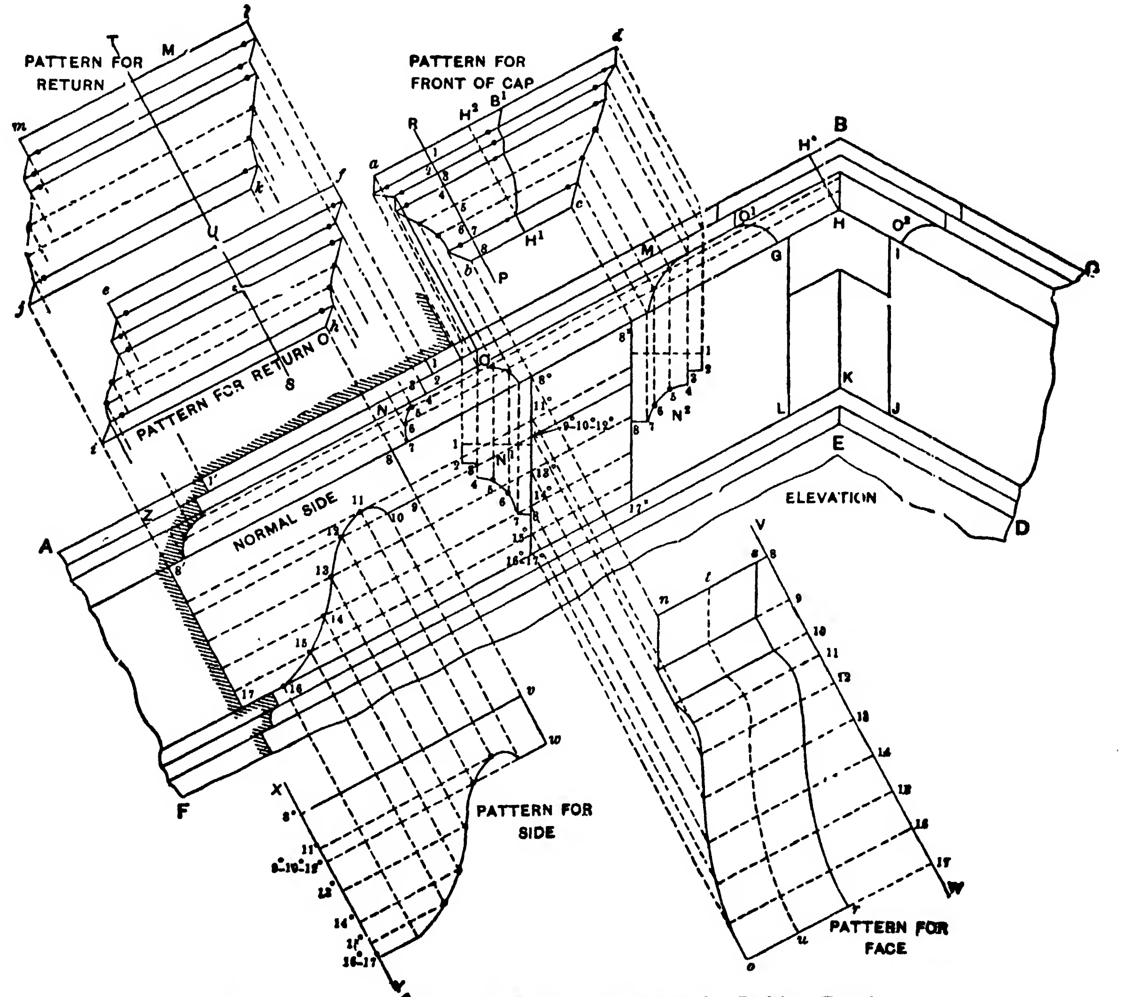


Fig. 79. Part of Front Elevation and Pattern for Raking Bracket

This is a method of obtaining the pattern for a raking bracket and molding, as shown in the accompanying illustration, Fig. 79, in which A B C D E F shows the part elevation of the cornice, 1′ 8′ 17 9 1 the normal side of cap and bracket, 8° 8^{x} 17^{x} 17° the face of the raking bracket and G H I J K L the face of the center bracket.

The first step is to obtain the modified profiles of the returns of the cap shown by O and M, for which proceed as follows: Divide the normal profile N into equal spaces, as shown from 1 to 8, through which extend lines indefinitely parallel to the lines of the cornice, as shown.

Take a tracing of N with the various points of intersections and place it in the position shown by N^1 and N^2, and from the various intersections erect vertical lines intersecting similar lines drawn from N. Trace a line through points thus obtained, resulting in O and M. Take a tracing of the profile O and place it upon the center bracket, as shown by O^1 and O^2, which completes the elevation of that view.

For the pattern for the face of the cap, draw the line P R at right angles to A B, upon which place the stretchout of the profile N, as shown from 1 to 8 on P R. Draw the usual measuring lines, which intersect by lines drawn from similar points of intersections in O and M, at right angles to A B, and resulting in the miter cuts *a b* and *d c*. Then *a b c d* is the pattern for the front of cap.

For the pattern for the front of the cap of the center bracket, take the distance from G to H and place it, as shown, from *b* to H^1. Erect the perpendicular H^1 H^2, and also the perpendicular H H° in the center bracket. Then measuring from this line, take the various distances to the miter line B H and transfer them to similar lines in the pattern for front, measuring from the line $H^1 H^2$. Trace a line through points thus obtained, then will H^1 B^1 *a b* be the pattern for the face of the center bracket.

For the pattern for the return caps O and M, take the stretchouts of O and M and place them on the line S U and U T drawn at right angles to A B. Draw the usual measuring lines, which intersect by lines drawn from similar points of intersections in the normal return Z N. Trace a line through points thus obtained, then *e f h i* is the return cap for O and *j k l m*, the return cap for M.

The pattern for the face of the bracket is obtained by dividing the normal side 8 17 into convenient spaces, as shown, from which lines are drawn parallel to A B until they intersect the side of the bracket in elevation, 8° 17° and 8^{x} 17^{x}. A stretchout of the normal side 8 17 is now placed upon the line V W, drawn at right angles to A B, as shown, from which the usual measuring lines are drawn and in-

tersected by lines drawn parallel to V W from similar points on 8° 17°, resulting in the miter cut *n o*.

Now take the distance of 8° 8^x and set it off on similar lines in the pattern for face and obtain the cut *s r*. Then *n o r s* is the full pattern for the face of the bracket. Take the distance G H in the center bracket, and set it off, as shown in the pattern, by the dotted line *t u*. Then *n o u t* is the pattern for the half face G H K L of the center bracket.

The last pattern is that for the side of the bracket, and is obtained by taking the various intersections on 8° 17° and placing them on the line 8′ 17 extended as X Y. Perpendiculars are drawn to X Y from the various points and intersected by lines drawn from similar points of intersections in the normal side at right angles to A B. Then 8° *v w* 17° is the pattern for the side.

PATTERN FOR A RAKING BALUSTER

To develop the pattern for an octagonal baluster in a raking balustrade, a general view of which is shown in Fig. 80, in which A shows a vertical baluster in a raking balustrade, B showing the cap and C the base. The problem gives an interesting study in drawing and projections, which, when accomplished, is more than half the battle in the developments of the patterns. The method for obtaining the patterns for the cap B will only be shown; as the same principles can be applied when laying out the patterns for base C.

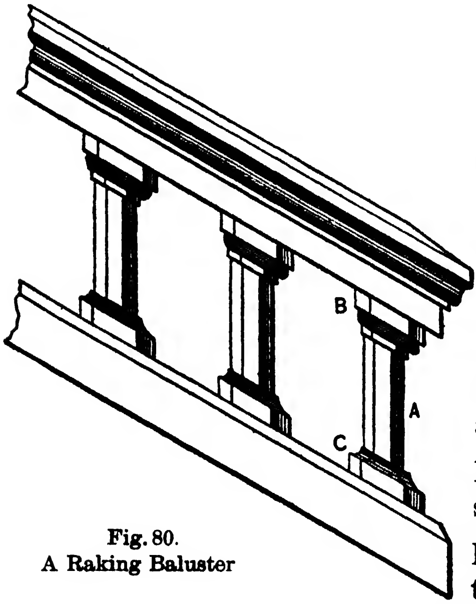


Fig. 80.
A Raking Baluster

In Fig. 81 let D E F G H I J K represent the plan view of the shaft of the baluster, and L M N O P Q R S the elevation of same placed in line above the plan, as shown. Let C in elevation represent the desired profile at right angles to O P, which will be called the given profile. Now divide this profile C into equal spaces, as shown by the small figures 1 to 8, and parallel to O P or L S draw lines indefinitely through these small figures, as shown. Take a tracing of the profile C and place it at right angles to D K in plan, as shown by C^1. Draw the outer plan of the cap, as shown by T Ú V W X Y Z &. Then draw the miter lines in plan, & V, T D, U E, V F, W G, X H, etc., as shown. Divide

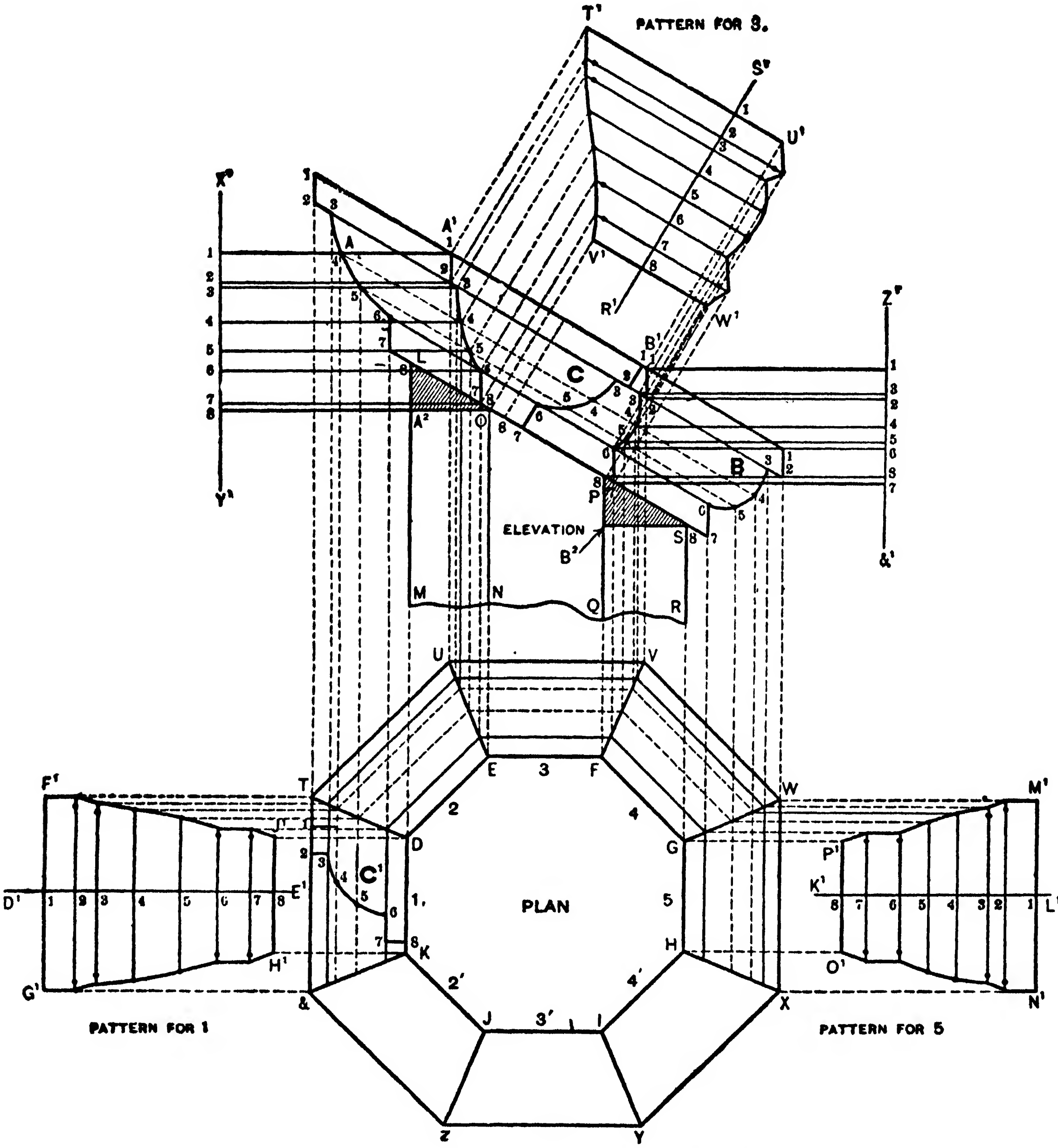


Fig. 81. Plan, Elevation, Miter Lines and Patterns

the profile C^1 in plan into the same number of equal spaces as the given profile C in elevation was divided, as shown from 1 to 8 in the profile C^1 in plan.

Through these small figures and parallel to K D draw lines intersecting the miter lines K & and T D. From the intersection on T D and parallel to D E draw lines intersecting the miter line E U. In similar manner from intersections on the miter lines E U, F V, G W, etc., and parallel to E F, F G, G H, etc., respectively, draw lines, as shown. Now parallel to K D and from intersections on the miter line T D carry lines upward, intersecting lines having similar numbers drawn through the profile C in elevation parallel to L S.

Trace a line through points thus obtained, as shown by 1 to 8 in profile A. Then will the profile A represent the true section or profile taken through that part of the cap shown by 1 in plan. In similar manner, parallel to H G and from the intersections on the miter line G W draw lines upward, intersecting lines of similar numbers drawn through the profile C in elevation parallel to L S. Trace a line thus obtained, as shown from 1 to 8 in profile B. Then will the profile B represent the true section or profile, taken through that part of the cap shown by 5 in plan. Now at right angles to U V in plan, and from intersections on the miter line U E, draw lines upward, intersecting lines of similar numbers in elevation, as shown. Trace a line through points from 1 to 8, then will A^1 O be the miter line in elevation, on U E in plan. In similar manner at right angles to U V and from intersections on V F carry lines upward, intersecting lines of similar numbers in elevation, as shown. Trace a line from 1 to 8, then will B^1 P be the miter line in elevation on F V in plan.

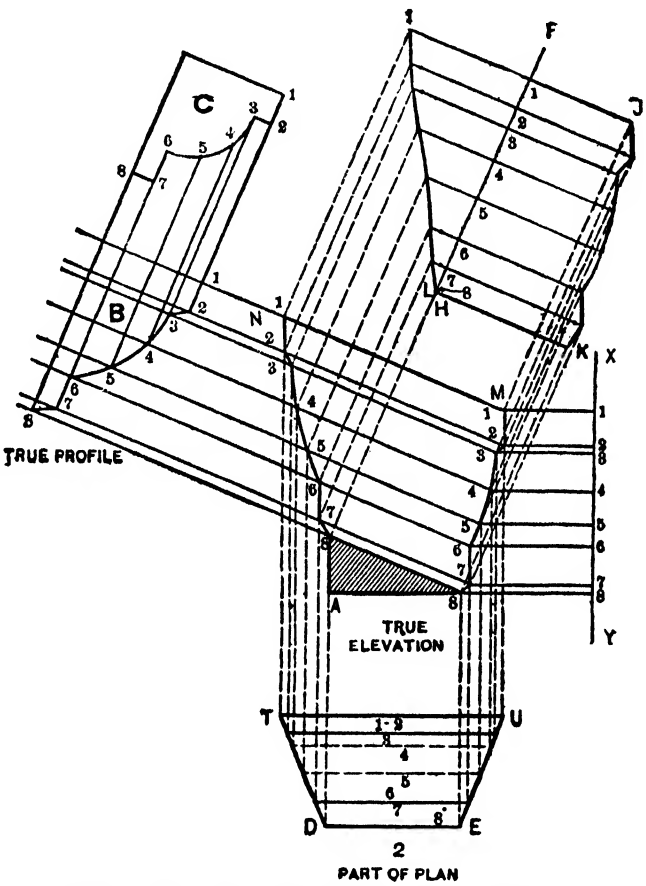


Fig. 82. Plan, True Elevation and Pattern for No. 2

The plan and elevation of the baluster is now completed and from which the patterns for parts 1, 3 and 5 shown in plan can be obtained. For the pattern for part 1 proceed as follows: At right angles to T & in plan draw the line D^1 E^1, upon which place the stretchout of profile A in elevation, being careful to carry each space separately onto the line D^1 E^1, as shown by the small figures 1 to 8. At right angles to D^1 E^1 and through the small figures draw lines, which intersect with lines having similar numbers drawn from the intersections on the miter lines T D and K & at right angles to T &. Trace a line through points thus obtained, then will F^1 G^1 H^1 J^1 be the pattern for part 1 in plan, formed after the profile A in elevation.

Now at right angles to W X in plan draw the line K^1 L^1, upon which place the stretchout of the profile B in elevation, being careful to carry each space separately onto the line K^1 L^1, as shown by the small figures. At right angles to K^1 L^1 and through the small figures draw lines, which intersect with lines having similar numbers drawn from the intersections on the miter lines G W and X H at right angles to W X. Trace a line through points thus obtained, then will M^1 N^1 O^1 P^1 be the pattern for part 5 in plan, and is to be bent after the profile B in elevation.

For the pattern for part 3 and 3′ in plan proceed as follows: At right angles to A^1 B^1 in elevation draw the line R^1 S^1, upon which place the stretchout of the given profile C, as shown by the small figures 1 to 8 on the line S^1 R^1. At right angles to R^1 S^1 and through the small figures draw lines, which intersect with lines having similar numbers drawn at right angles to A^1 B^1 from the intersections on the miter lines A^1 O and B^1 P. A line traced through points thus obtained, as shown by T^1 V^1 W^1 U^1, will be the pattern for the parts 3 and 3′ in plan, formed after the profile C in elevation, one right and one left.

For the patterns for parts 2 and 4 true elevations must be constructed, but before doing so the vertical hight of the intersections on the miter lines A^1 O and B^1 P must be obtained as follows: Draw any vertical lines in the positions shown as X^1 Y^1 and Z^1 $\&^1$. At right angles to these two vertical lines X^1 Y^1 and Z^1 $\&^1$, and from the intersections 1 to 8 on both miter lines A^1 O and B^1 P, draw lines intersecting the lines X^1 Y^1 and Z^1 $\&^1$, respectively, as shown by small figures 1 to 8 on both. Now take a tracing of T U E D or part 2 (all eight parts being alike), and place it as shown by T U E D or part 2 in Fig. 82, being careful to have the various intersecting lines and numbers as shown. Draw any horizontal line, as A 8, in length equal to D E in plan, as shown. At right angles to A 8 draw the line A 8′, equal in hight to A^2 8 in elevation in Fig. 81. Then draw a line from 8 to 8′ in Fig. 82. Take the various hights on the line X^1 Y^1 in Fig. 81 and place as

shown by X Y in Fig. 82, being careful that the point 8 is placed so that it will meet the line A 8 extended, as shown. At right angles to X Y and from the points 1 to 8 on same draw lines which intersect with lines drawn from intersections having similar numbers on U E in plan at right angles to D E. Through the points of intersections thus obtained trace a line, as shown by the small figures, or from 8 to M. Now parallel to 8 8′ and from intersections on the miter line M 8 draw lines indefinitely, as shown, which intersect with lines drawn from intersections on T D in plan having similar numbers at right angles to D E. Trace a line through

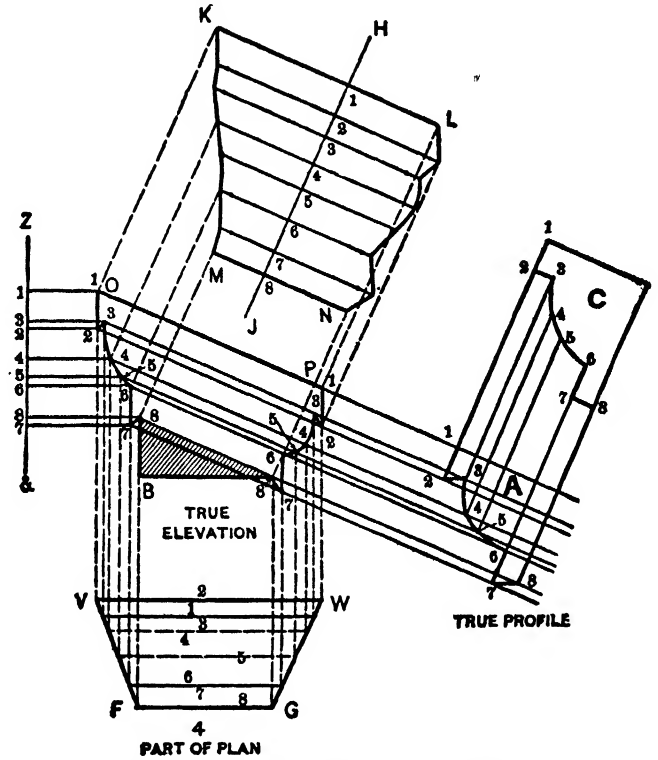


Fig. 83. Plan, True Elevation and Pattern for No. 4

intersections thus obtained, as shown by the small figures, and from N to 8′. Then will N M 8 8′ be the true elevation for part 2 and 2′ of the baluster in plan in Fig. 81.

Before obtaining the pattern for part 2 a true profile must be obtained at right angles to N M in Fig. 82, for which proceed as follows: Take a tracing of the given profile C in elevation in Fig. 81 and place it, as shown, at right angles to M N extended in elevation in Fig. 82, as shown by C. At right angles to M N and from the various points 1 to 8 in the profile C draw lines, as shown, intersecting lines of similar numbers drawn from the intersections in the miter line M 8.

Trace a line through points thus obtained, as shown, then will B be the true profile. For the pattern proceed as follows: At right angles to M N draw the line H F, upon which place the stretchout of profile B, being careful to carry each space separately onto the line H F, as the divisions are unequal, as shown by the small figures 1 to 8 on H F. Now at right angles to H F and through the small figures draw lines which intersect with lines drawn from intersections in N 8′ and M 8 having similar numbers at right angles to N M. Trace a line through points thus obtained, then will L I J K be the pattern for part 2 and 2′ formed after the profile B, one right and one left.

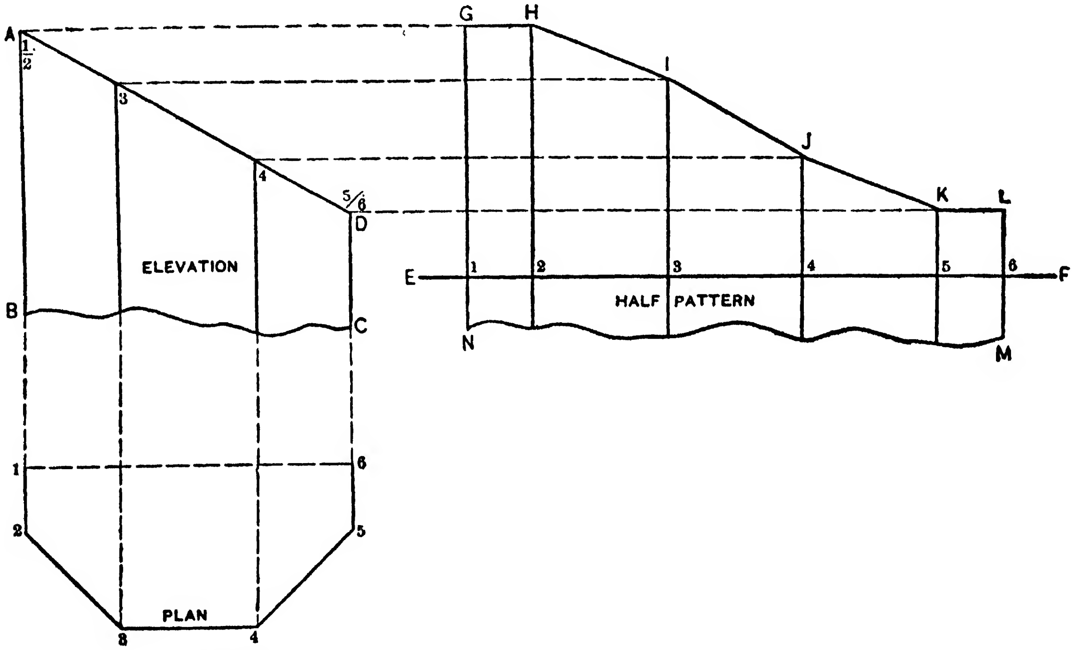


Fig. 84. Plan, Elevation and One-Half Pattern for Shaft at Top.

For the pattern for part 4 and 4′ in plan in Fig. 81 proceed as shown in Fig. 83, in which F G W V is a reproduction of F G W V in plan in Fig. 81. Draw any horizontal line, as B 8, in Fig. 83, equal in length to F G in plan, as shown. At right angles to 8 B draw B 8′ equal to B^2 8 in elevation in Fig. 81, and draw a line from 8 to 8′ in Fig. 83. Take the various hights on the line Z^1 &^{1} in Fig. 81 and place as shown by Z & in Fig. 83, being careful that the point 8 is placed so that it will meet the line drawn at right angles to B 8′ from the point 8′, as shown. Referring to Fig. 82, it will be noticed that the vertical hights on X Y are placed to the right of the triangle A 8 8′, because the hights are taken from the miter line A^1 O in elevation in Fig. 81, which is to the right of the triangle L A^2 O; while in

Fig. 83 the vertical hights on Z & are placed to the left of the triangle 8 B 8' because the hights are taken from the miter line B^1 P in elevation in Fig. 81, which is to the left of the triangle P B^2 S. Bearing this in mind, now at right angles to Z & in Fig. 83, and from points 1 to 8 on same, draw lines which intersect with lines drawn from intersections having similar numbers on V F at right angles to F G. Through points of intersections thus obtained trace a line, as shown by the small figures, or from 8' to O. Parallel to 8 8' and from intersections on the miter line O 8' draw lines indefinitely, as shown, which intersect with lines drawn from intersections on C W in plan having similar numbers at right angles to F G. Trace a line through intersections thus obtained, as shown by the small figures, and from P to 8. Then will O P 8 8' be the true elevation for part 4 and 4' of the baluster shown in plan in Fig. 81. For the true profile, at right angles to O P in Fig. 83 take a tracing of the given profile C in elevation in Fig. 81 and place it as shown at right angles to O P extended in Fig. 83 by C. At right angles to O P and from the various points 1 to 8 in the profile C draw lines, as shown, intersecting lines of similar numbers drawn from the intersections in the miter line O 8'. Trace a line through points thus obtained, as shown, then will A be the true profile.

At right angles to O P draw the line J H, upon which place the stretchout of the profile A, as shown by the small figures on the line H J. Now at right angles to H J and through the small figures draw lines which intersect with lines drawn from intersections having similar numbers in O 8' and P 8 at right angles to O P. Trace a line through points thus obtained, then will K L N M be the pattern for part 4 and 4' formed after the profile A, one right, the other left.

This completes the entire patterns for the cap of the baluster. For the cut of the baluster shaft at the top proceed as shown in Fig. 84, in which 1 2 3 4 5 6 represents the half plan of the baluster shaft reproduced from the plan in Fig. 81, and A B C D in Fig. 84 shows the elevation of the shaft similar to L M R S in Fig. 81. For the pattern draw the line E F in Fig. 84 at right angles to C D, and upon it place the stretchout of the half plan, as shown by similar figures 1 to 6. At right angles to E F and through the small figures draw lines, which intersect with lines drawn from intersections having similar numbers on A D at right angles to C D. Trace a line through points thus obtained, then will G H I J K L M N be the half pattern for the shaft of the baluster. The reverse cut of this pattern will answer for the pattern for the shaft, butting against the base of the baluster as at C in Fig. 80.

PATTERNS FOR COMPLICATED RAKING MOLDINGS

In the accompanying illustration, Fig. 85, is shown the plan and elevation of a gable molding with horizontal returns at either end, at an acute and obtuse angle, respectively. Owing to the different angles in plan, it will require four different profiles and patterns to miter the various molds. If the miter line of the gable were allowed to run at right angles to F G in plan, as shown by J x, it would only be necessary to obtain one profile for the gable mold; but as it is desired that the miter line of the gable shall be a continuation of the ridge line I J, as J K, makes it necessary to obtain two profiles.

Let E F G H represent the plan of the wall of the building and I J the line of the ridge parallel to G H. Bisect the angles G and F as indicated by u v w and and r s t, respectively. Draw the miter lines t F and w G, extending them indefinitely. In its proper position above the plan draw the gable F° J° G°, making the rise N J°, as desired. In this case it is desired that the normal or given profile be placed on the horizontal return F E in plan, as shown by the profile A.

The first step is to divide this profile into an equal number of spaces, as shown from 1 to 11, through which points, parallel to E F, lines are drawn until they intersect the miter line F M from 1 to 11. From these intersections lines are drawn parallel to F G, crossing the miter line J K as shown, and intersecting the miter line G L, also from 1 to 77, from which intersections lines are carried parallel to G H, if desired.

Now take a tracing of the given profile A in plan and place it in the position shown by A^1 in elevation, being careful that points 10-11 are in line with G° F°, extended as shown. From the various intersections in A^1 horizontal lines are drawn and intersect vertical lines erected from similar numbered intersections on the miter line F M in plan, resulting in the miter line M° to F° in elevation, when a line is traced through points thus obtained.

From the intersections 1 to 11 in M° F° lines are drawn parallel to F° J° and intersected by vertical lines drawn from similar numbered intersections on the miter line J K in plan, partly shown by 2, 3 and 11. A line traced through points thus obtained, as shown from K° to J°, will be the miter line at the gable juncture. From the intersections 1 to 11 in the miter line J° K° lines are drawn parallel to J° G° and intersected by lines erected from the intersections on G L in plan, resulting in the miter line L° G° in elevation. This completes the miter lines in elevation, from which patterns are obtained, but to obtain the girths of these patterns modified profiles must be obtained, as follows:

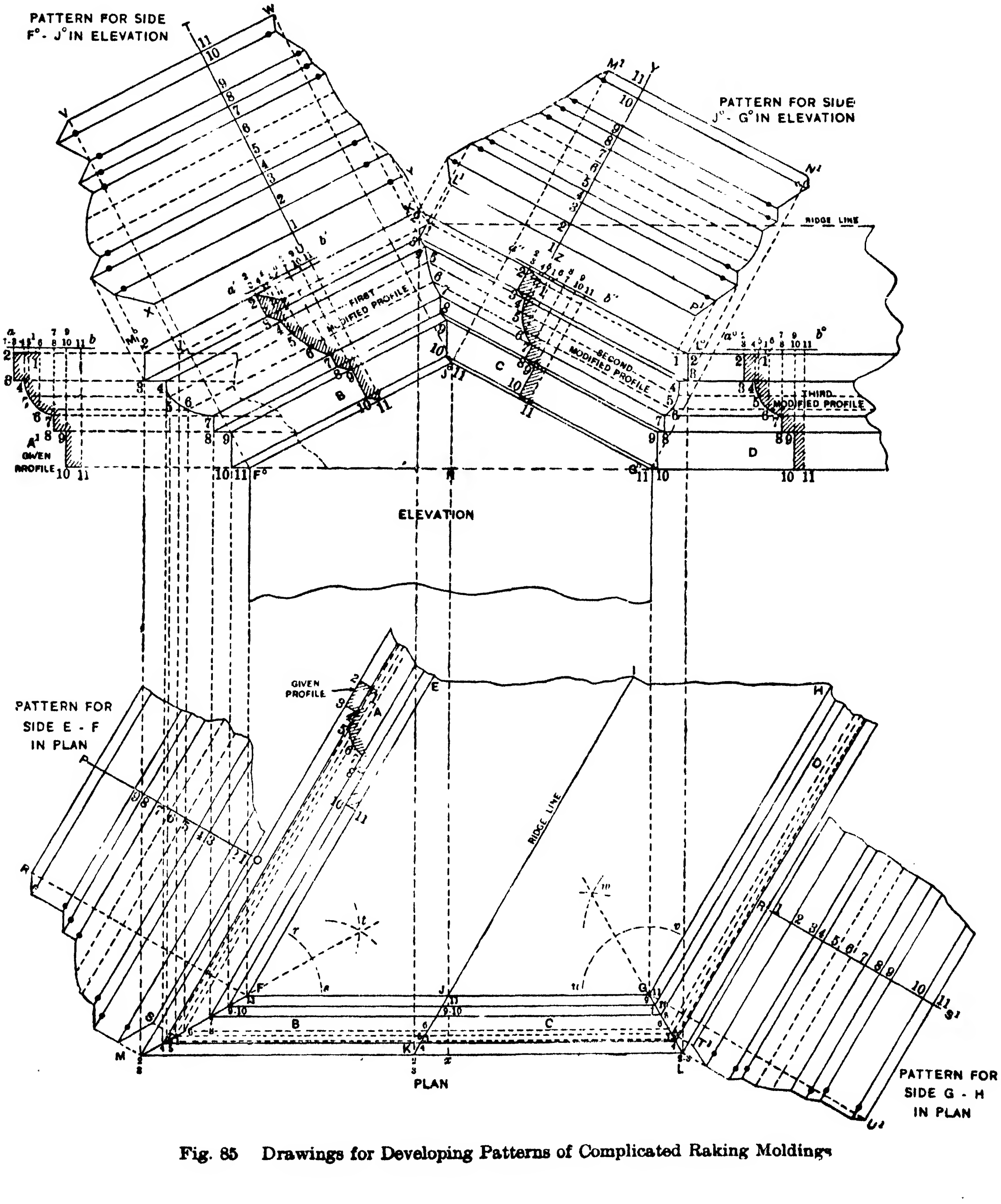


Fig. 85 Drawings for Developing Patterns of Complicated Raking Moldings

Obtain the projections of the various points in the given profile A^1, on the horizontal line $a\ b$, and place it in the positions shown by $a'\ b'$, $a''\ b''$ and $a^\circ\ b^\circ$, the line in each case being drawn parallel to the line of the molding, as shown. Perpendiculars are now drawn intersecting similar numbered lines in the molding Trace lines through points thus obtained; then B is the modified profile for the left gable mold, C the modified profile for the right gable mold and D the modified profile for the right horizontal return.

Having obtained the miter lines and profiles, the patterns are developed as follows: On the line O P, drawn at right angles to F E in plan, place the girth of the profile A, or A^1, as shown from 1 to 11 on O P. Through these points draw lines parallel to F E and intersect same by lines drawn at right angles to F E from similar numbered intersections on the miter line F M. Trace a line through points thus obtained; then will P O S R be the pattern for the side F E in plan. In similar manner on the line $R^1\ S^1$, drawn perpendicular to G H in plan, place the girth of the third modified profile D, as shown, from 1 to 11 on $R^1\ S^1$, through which draw lines parallel to G H, intersecting same by lines drawn from similar intersections on the miter line G L in plan, at right angles to G H, and resulting in the pattern $R^1\ T^1\ U^1\ S^1$ for the side G H in plan.

The horizontal return patterns were obtained from the plan, while the gable patterns will be obtained from the elevation. At right angles to $F^\circ\ J^\circ$ draw the line T U, upon which place the girth of the modified profile B. Through the points draw the usual measuring lines, which intersect by lines drawn at right angles to $F^\circ\ J^\circ$, from similar intersections on the miter lines $M^\circ\ F^\circ$ and $K^\circ\ J^\circ$ in elevation. A line traced through points thus obtained, as shown by V W Y X, will be the pattern for the left gable mold. The pattern for the right gable mold is obtained similarly, as indicated.

MITERING A DORMER AGAINST A DOME

For an accurate solution of this problem—that is, the miter of a molding against a spherical surface—the following demonstration and diagrams are appended: Let A B C, in Fig. 86, be one-quarter of the plan of a round dome, and D E a profile of the same. Let F H represent the profile of the return molding placed in its proper position, as shown, and H J part of the line of the dormer window. Draw a soffit plan of the molding, as shown by K L M N. Now divide curved portion of the profile F H into an equal number of spaces, as shown, and drop perpendicular lines from the spaces in F H until they intersect

the miter line M O in plan. Then from the intersections on the miter line M O, and parallel to M N, draw lines until they intersect the plan of the round dome C A, as shown from K to N. At right angles to B A in plan, and from intersections on the curve K N, draw lines until they intersect the base of the dome P D. Place one point of the dividers at P, the center from which the dome is struck, and bringing the pencil points successively to the several points of intersection just obtained on the base line P D, draw arcs from each intersecting horizontal line of corresponding number drawn on the profile F H, as shown by the intersections $1^1, 2^1, 3^1$, etc. The line R S T, traced through points of intersection thus obtained, will represent the miter line in elevation from which the pattern is obtained. For the pattern proceed as follows: At right angles to R F in elevation draw the stretchout line V W, upon which place the stretchout of the profile of the molding F H, as shown by the small figures 1, 2, 3, 4, etc. At right angles to W V, and through the small figures, draw the measuring lines, which intersect with lines of similar numbers drawn from the intersections in the miter line in elevation R S T and the profile F H at right angles to R F. Trace a line as shown from X to Y in pattern, which will be the square miter cut for the dormer return. It will be noticed that the pat-

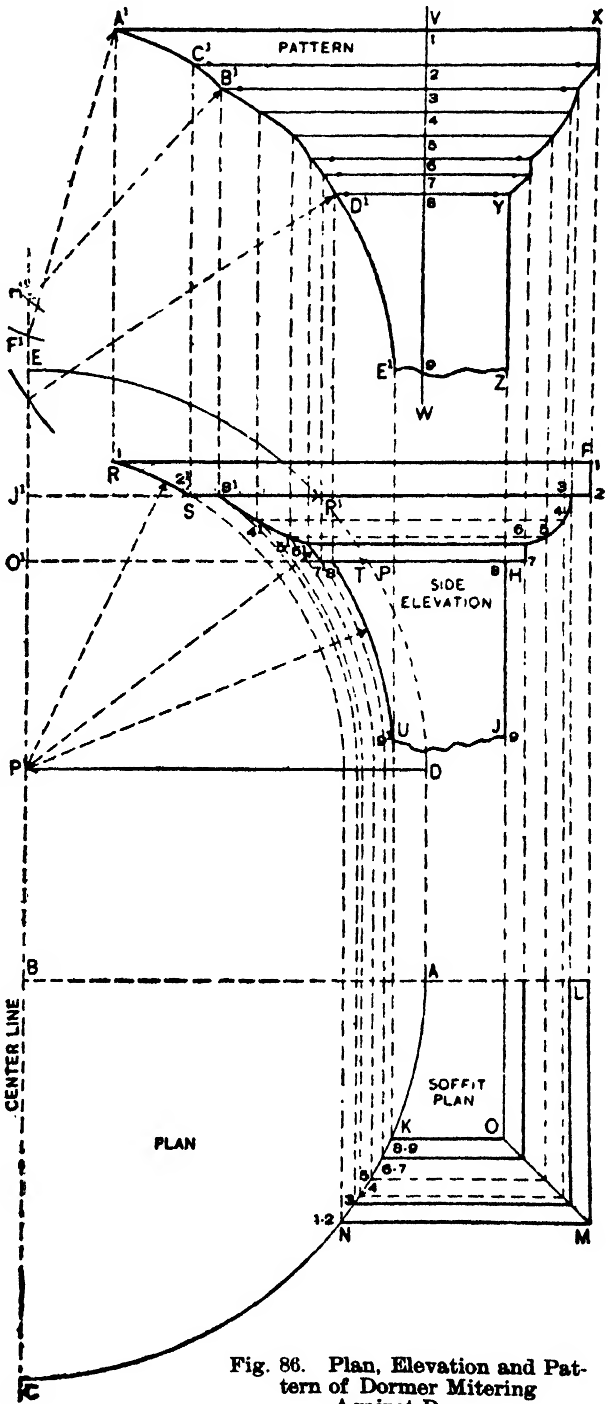


Fig. 86. Plan, Elevation and Pattern of Dormer Mitering Against Dome

tern for the miter cut at the other end of the molding will require arcs, which are struck from centers corresponding to the arcs shown in the miter line in elevation. To strike these arcs, proceed as follows: Extend the center line, above the elevation, as shown; now, with P R or P S in elevation as radius, and with A^1 in pattern as center, strike an arc intersecting the center line at F^1. Then with F^1 as center, and using the same radius, draw an arc shown from A^1 to C^1. As that part of the profile shown from 2 to 3 in the profile F H meets the dome on a horizontal plane, the arc shown from C^1 to B^1 in pattern will be struck with a radius equal to J^1 P^1 in elevation. Then with C^1 or B^1 in pattern as center, and a radius equal to J^1 P^1, draw an arc intersecting the center line at H^1. Then with H^1 as center, and with the same radius, strike arc shown from C^1 to B^1.

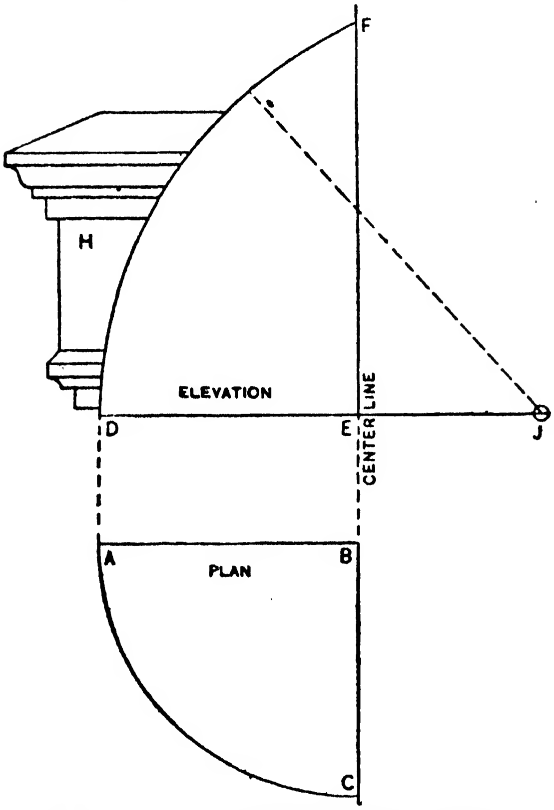


Fig. 87. Dormer Mitering Against Irregular Curved Dome

Now trace a line from B^1 to line 6 in pattern. The arc shown between lines 6 7 in pattern will be struck with a radius equal to P 6^1 or P 7^1 in elevation, while the arc shown between lines 7 8 in pattern will be struck with a radius equal to O^1 P^1 in elevation. Then will A^1 C^1 B^1 D^1 Y X be the pattern for the return of the dormer molding against the dome. The arc shown from D^1 to E^1 in pattern is struck, as previously explained, with the radius shown in elevation by P T or P U.

In Fig. 87 is shown a dome of similar construction, and the principles employed in obtaining the pattern in Fig. 86 can also be applied to Fig. 87. A B C represents the plan, D E F the elevation, and H the side of the dormer. The method shown in Fig. 86 should be applied in the same manner for Fig. 87, with the exception that the center point with which the dome is struck in Fig. 86 lies in the center line, while in Fig. 87 the center point lies outside of the center line, as shown at J. After the intersections are obtained on the base line of dome D E, Fig. 87, J would be struck to intersect with horizontal lines, as explained in connection with Fig. 86.

PATTERN FOR MOLDINGS MITERING AGAINST CONCAVE CONICAL TOWER

This problem deals with the method of how to cut the pattern for the moldings on the sides of a dormer window mitering against a concave conical tower, shown in the accompanying illustration, Fig. 88, in which E F G H represents a partial elevation of the tower, and I J K the side of the dormer window which is to miter against the tower. In this connection it may be proper to remark that it is not necessary when obtaining the pattern to draw a full elevation of the tower; all that is required being the center line of the tower and as much of the curve of the tower as will be necessary to receive the side of the dormer. Draw any vertical line, as A B, which represents the center line; let E F and H G represent the half diameters of the tower at these points respectively, then draw the desired curve or sweep F G. In its proper position draw the profile or side of dormer indicated by J K. Divide the curved portion of the profile into equal spaces, as shown by the small figures 1 to 8, introducing two extra points, X and Y, as shown. Now at right angles to the center line A B and through the various points draw lines intersecting the curve of the tower F G between I and K.

From any convenient point, as C on the center line, and at right angles to A B, draw the line C D. At right angles to C D and from the various intersections on the curve I K draw lines intersecting C D at points 1, Y, X, 2, 3, etc., corresponding to lines of similar numbers in the profile J K. Now with C as center, and with radii equal to the distances to the various points shown by the small figures on the line C D, draw arcs as shown. At right angles to the center line C D in plan, set off half the width of the dormer window, as at Z. Now take a tracing of the side of the dormer J K in elevation and place it as shown by J^1 K^1 in plan, placing the line 1 2 parallel to the center line in plan, as shown. Space the profile into the same number of parts as shown in elevation, then parallel to C D and from the various points in the profile J^1 K^1 draw lines intersecting arcs of similar numbers, as shown by points 1 to 8 in plan. A line traced through points of intersections thus obtained will show the line of intersection between the side of the dormer and the roof of the tower. Now at right angles to C D and from the various points of intersection in the miter line in plan 1 to 8 draw lines upward intersecting lines of similar numbers in elevation drawn from the profile J K parallel to I J. A line traced through points of intersection thus obtained, as shown from 1^1 to 8^1, will be the miter line in elevation, showing the

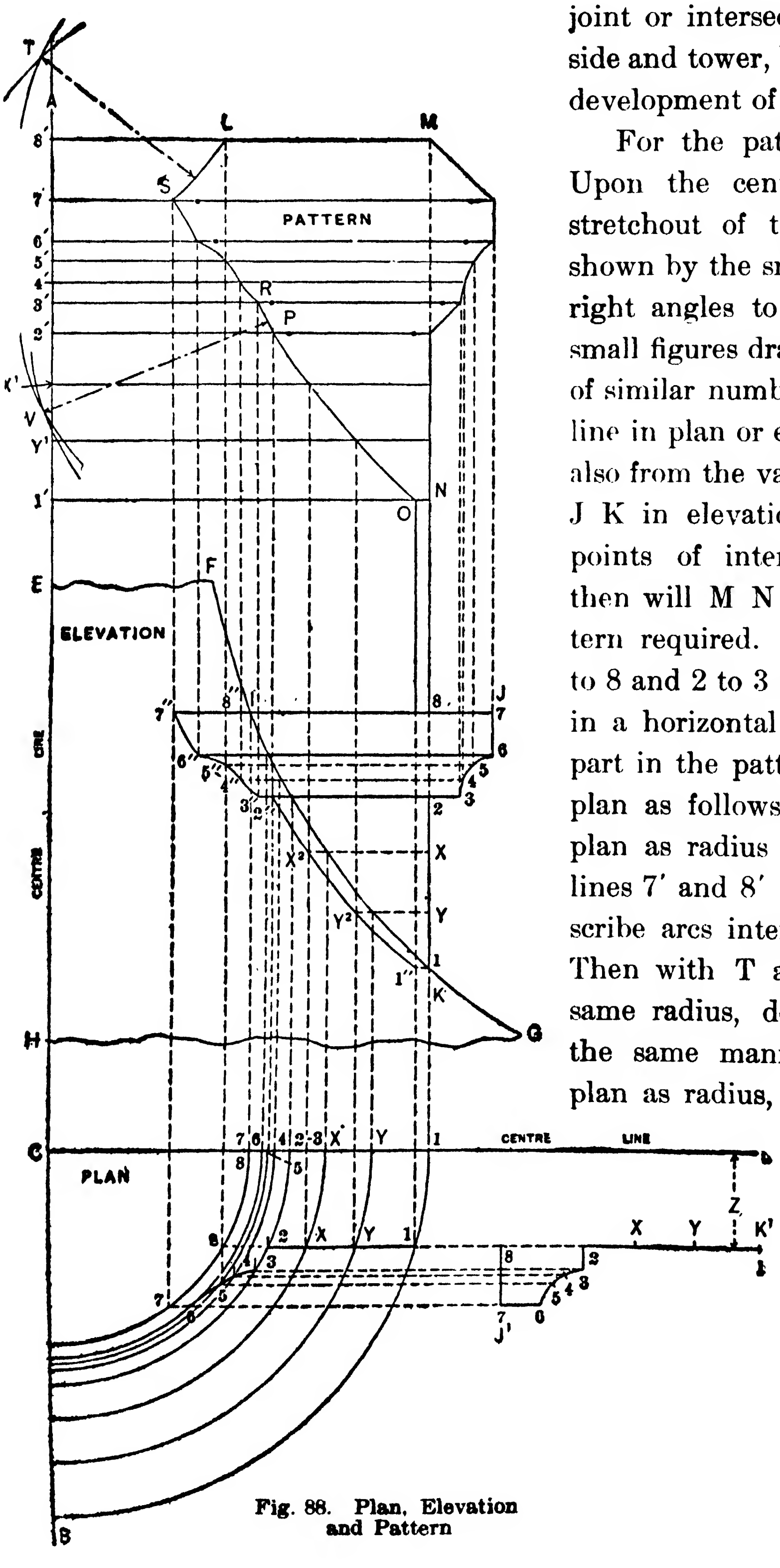


Fig. 88. Plan, Elevation and Pattern

joint or intersection between the dormer side and tower, but is not necessary in the development of the pattern.

For the pattern proceed as follows: Upon the center line A B place the stretchout of the molding 8 J K, as shown by the small figures on A B. At right angles to A B and through the small figures draw lines intersecting those of similar numbers drawn from the miter line in plan or elevation parallel to A B, also from the various points to the profile J K in elevation. Trace lines through points of intersections thus obtained; then will M N O P R S L be the pattern required. As the distances from 7 to 8 and 2 to 3 in profile in elevation lie in a horizontal plane, the shape of that part in the pattern is obtained from the plan as follows: With C 7 or C 8 in plan as radius and points S and L on lines 7′ and 8′ in pattern as centers, describe arcs intersecting each other at T. Then with T as center, and using the same radius, describe the arc L S. In the same manner with C 2 or C 3 in plan as radius, and points R and P on lines 2′ and 3′ in pattern as centers, describe arcs intersecting each other at V; then with V as center, using the same radius, describe the arc RP.

HORIZONTAL MOLDING AND CURVED WASH

To lay out the patterns for the intersection of a horizontal molding, A, with the curved wash D of the accompanying illustration, Fig. 89, in which J K L shows half the elevation of the curved molding, struck from the center C, and M N O P the elevation of the horizontal molding; let R^1 S^2 S be the true section of the curved molding taken on the line K L in elevation and T^1 be the true

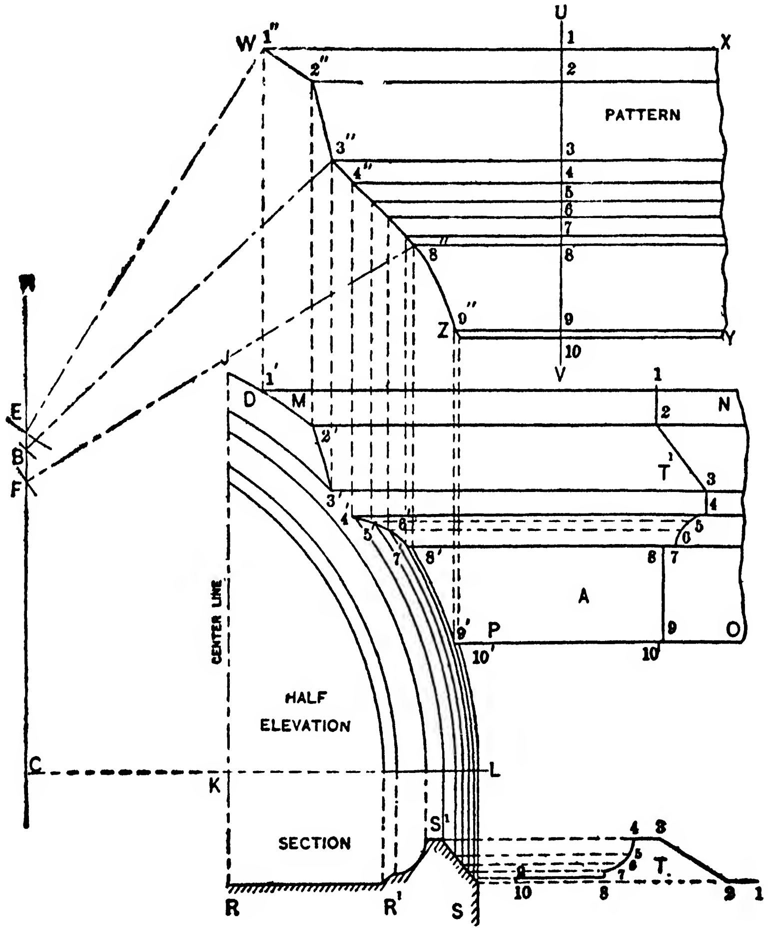


Fig. 89. Elevation, Sections and Pattern

profile of the horizontal molding, as shown. Before obtaining the pattern it will be necessary to obtain the miter line of the horizontal molding against the curved wash, as shown by M P in elevation, for which proceed as follows: Take a duplicate of the profile T^1 of the horizontal molding and place it, as shown by T, in the section over the wash S S^1. Now divide the profile T into any number of

equal spaces, as shown by the small figures 1 to 10; then from these divisions and parallel to 1 to 10 draw lines intersecting the wash S S^1, as shown. At right angles to K L in elevation and from the intersections on the wash S S^1 draw lines intersecting the base line K L. Then using C as the center, and with radii equal to the distances from C to the several intersections, draw arcs, which intersect with lines of similar numbers drawn parallel to M N from the divisions in the profile T^1 which is spaced similar to the profile T. A line traced through intersections thus obtained, as shown by 1′ to 10′, will be the miter line.

For the pattern proceed as follows: At right angles to M N draw the line U V, upon which place the stretchout of the profile T^1, as shown by the small figures. At right angles to U V and through the small figures draw lines, which intersect with lines drawn at right angles to M N from intersections of similar numbers in the miter line M P. Trace a line from 2″ to 3″, from 4″ to 8″ and 9″ to the line 10 in pattern. The balance of the spaces are arcs of circles, and are obtained as follows: With C 1″ as radius and 1″ in pattern as center describe an arc intersecting at E the line C H, which is erected from C at right angles to C L. Then with E as center and using the same radius draw the arc 1″ 2″ in pattern, which is the same as 1′ 2′ in elevation. Now with C 3′ in elevation as radius and 3″ in pattern as center describe an arc intersecting the line C H at B. Then with B as center and using the same radius describe the arc 3″ 4″. Finally with C 8′ in elevation as radius and 8″ in pattern as center describe an arc intersecting the line C H at F. Then with F as center and with similar radius describe the arc 8″ 9″ in pattern. Then will W X Y Z be the pattern for the miter cut against the required curved wash.

OCTAGON BASE OVER CIRCULAR WINDOWS

To obtain the patterns for an octagon base to fit over two circular windows, similar to the diagram Fig. 90 in which A and B represent the circular windows over which the octagon base D C E is to fit, F H I J K being plan view. At right angles to E D, and from the point of the base C erect a line, intersecting the line J F in plan of K; then from the corners H and I draw the miter lines H K and K I. As the given profile of the octagon base D C E in elevation is a true section on the line J F in plan, it will be necessary to obtain true sections at right angles to the lines J I and I H in plan before the patterns can be obtained. To do this, proceed as follows:

Divide the half profile of the base C D into equal spaces, as shown by the small figures 1 to 9; then at right angles to E D, and from the small intersections, draw lines intersecting the line J F in plan, as shown. Now from the intersections on J K, and parallel to J I, draw lines intersecting the miter line I K; then parallel to H I, and from the intersections on I K, draw lines inter-

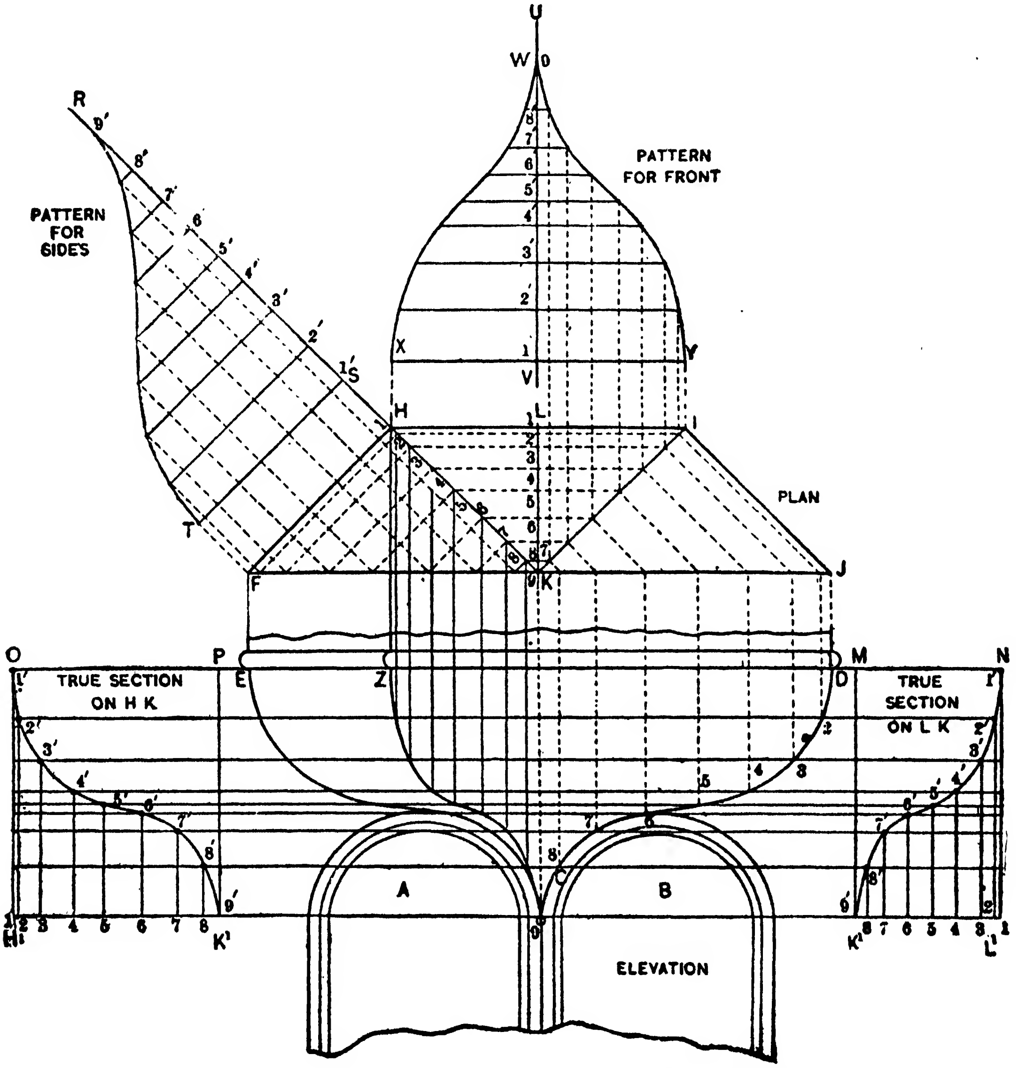


Fig. 90. Detail of Window Base and Method of Developing Patterns

secting the miter line H K. From these intersections and parallel to H F, draw lines intersecting F K. Through the intersections 1 to 9 in the profile C D in elevation draw line indefinitely, parallel to E D right and left. Now, at right

angles to H I in plan, and from the point K, erect the line K L, as shown. Take the distance K L, with the various intersections on same, and place it on the horizontal line 9, drawn from 9 in elevation, as shown by K^1 L^1. At right angles to K^1 L^1 and from the small figures, draw lines, intersecting horizontal lines of similar numbers, as shown, from 1′ to 9′. From K^1, and at right angles to K^1 L^1 erect the line K^1 M. Trace a line from 1^1 to 9^1; then will M N K^1 be the true section on the line L K in plan.

For the section at right angles to F H or I J in plan proceed as follows: In this case it happens that the miter line H K in plan is at right angles to H F; therefore take the distance H K, with the various intersections on same, and place it on the horizontal line drawn from the point 9 in elevation, as shown by H^1 K^1. At right angles to K^1 H^1 and through the small figures, erect lines intersecting lines of similar numbers drawn from the points in profile D C. Trace a line through points thus obtained as shown from 1′ to 9′. From K^1, at right angles to K^1 H^1 erect the line K^1 P. Then will O P K^1 be the true section on H K in plan.

For the pattern for the front H I K proceed as follows: At right angles to H I erect any line, as U V, upon which place the stretchout of the section M N K^1, being careful to transfer each and every space separately, as shown by the small figures 1′ to 9′ on the line U V. At right angles to U V, and through the small figures, draw lines, which intersect with the line drawn from the intersections of similar numbers on the miter line I K at right angles to H I. Trace a line thus obtained, as shown by W Y. Trace the miter cut opposite the line U V, as shown by W X. Then will W X Y be the pattern for front. Proceed in similar manner for patterns for side. In line with H K in plan, or at right angles to H F, draw the line R S, upon which place the stretchout of the section O P K^1, transferring each and every space separate, as shown by the small figures, 1 to 9′ on the line R S. At right angles to R S and from the small figures, draw lines, which intersect with lines drawn from the intersections on F K, having similar numbers at right angles to F H. As the miter line H K is at right angles to H F I the pattern cut for that mitre will result in a straight line, as shown by R S. Trace a line from R to T, and R S T will be the pattern for the two sides, one formed right, the other left. If for any reason it is desired to show the miter line in elevation on the line H K in plan, it can be done as follows: At right angles to F J, and from intersections on H K, drop solid lines, as shown, intersecting lines of similar numbers in elevation. Trace a line through points thus obtained, as shown by Z 9.

PATTERN FOR BOTTOM ON BAY WINDOW

This is an exemplification of the method of cutting the pattern of the bottom of a bay window when the miter lines A B, C D, E F, and G H must be made as drawn in elevation, so as to conform with the architecture of the bay. A section through I J is shown at K L M, the miter lines in the plan being curved.

The plan and elevation, Fig. 91, are an illustration of the bay window in

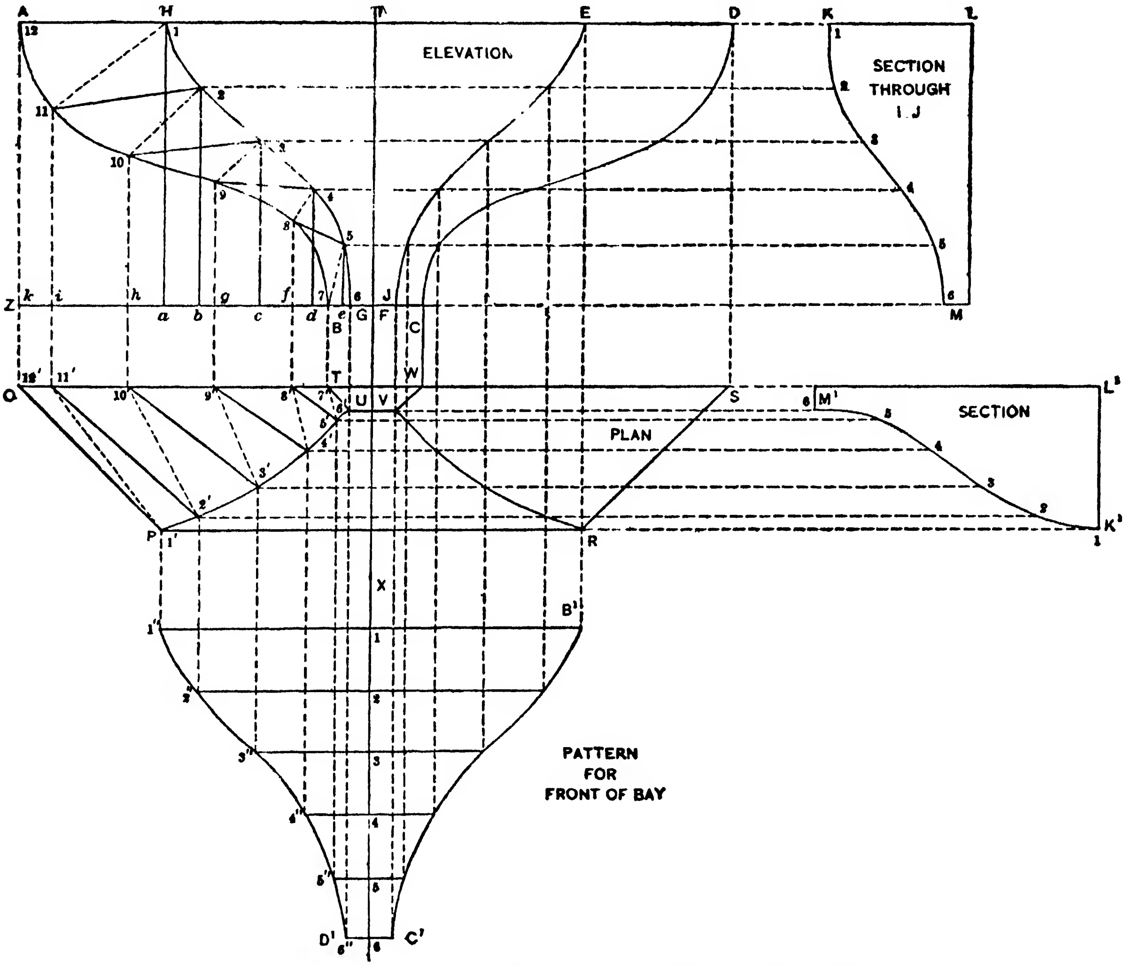


Fig. 91. Detail of Bottom of Bay, True Sections and Pattern

which A B C D represent the true profile of the outline of the bay against the wall O S in plan, while E F G H represents the given miter lines in elevation. K L M is the true given section on I J in elevation, and O P R S the plan view on the line A D in elevation, while T U V W is the plan view on B C in elevation. With the elevation, section and plan in their relative positions, the

first step is to obtain the miter lines in plan, for which proceed as follows: Divide the section K L M into equal spaces, as shown by the small figures 1 to 6. At right angles from L M and from these intersections draw lines intersecting the given miter lines E F and G H in elevation, as shown by the points 1 to 6 on the miter line G H. Now take a duplicate of the section K L M, and placing the lines L^1 M^1 of the section to correspond with O S of the plan, divide the profile K^1 M^1 into the same number of divisions as are contained in K M of the elevation. Now parallel to K^1 M^1 and through the small figures draw lines into the plan, which intersect with lines of similar numbers drawn from the intersec-

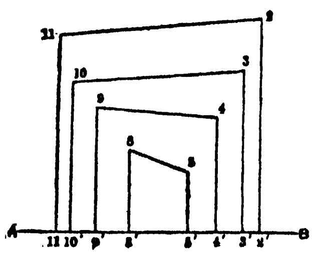


Fig. 92

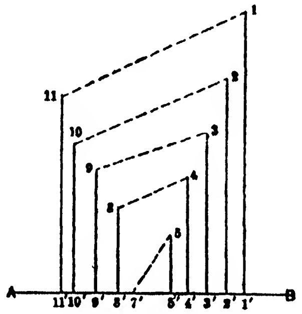


Fig. 93

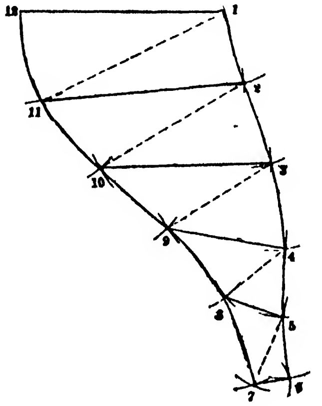


Fig. 94

Diagram of Triangles and Pattern of Sides

tions on the miter lines H G and F E in elevation at right angles to O S in plan. Lines traced through the point just obtained will give P U and V R as the miter lines in plan.

Having obtained the miter lines in plan, the pattern for the front of the bay can be developed as follows: Upon the center line I J, extended as X Y, place a stretchout of the section K M, as shown by the small figures 1 to 6. At right angles to X Y and through the small figures draw lines, which intersect with those drawn from intersections having corresponding numbers on the miter lines in plan T U and V R at right angles to P R. Trace a line through the points thus obtained and A^1 B^1 C^1 D^1 will be the pattern for the front of the bay, shown in plan by P U V R and in elevation by E F G H.

As it will be impossible to obtain the patterns for the sides of the bay by means of parallel lines the triangulation method will be employed. As all sides are the same only one will be developed. As the miter line H G in elevation is divided into five equal spaces, divide the profile A B into five equal spaces. The miter line H G being numbered 1 to 6 continue the numbers on the profile B A

from 7 to 12, as shown. Now connect solid lines from 2 to 11, 3 to 10, 4 to 9 and 5 to 8, and dotted lines from 1 to 11, 2 to 10, 3 to 9, 4 to 8 and 5 to 7. Project the intersections 7 to 12 onto plan on the line O S, as shown by the dotted lines and from 7′ to 12′. Number the intersections on the miter line P U in plan to correspond with those on the miter line G H in the elevation, as shown by 1′ to 6′ in plan. Now draw solid lines in plan from 2′ to 11′, 3′ to 10′, 4′ to 9′, 5′ to 8′ and dotted lines from 1′ to 11′, 2′ to 10′, 3′ to 9′, 4′ to 8′ and 5′ to 7′. Extend the line C D in elevation, as shown by C Z. Now from the various intersections 1 to 12 in elevation draw vertical lines intersecting the line C Z at *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, *i*, *k*. Then will the solid and dotted lines in plan represent the bases on the vertical lines just drawn in elevation the altitudes for the sections, which are constructed as follows: In Fig. 92 draw any horizontal line, as A B, upon which place the various lengths of the solid lines shown in plan, Fig. 91, as indicated by similar numbers in Fig. 92. At right angles to A B and through the small figures draw lines equal to hights of similar numbers in elevation, Fig. 91, all as is shown in Fig. 92. For example, take the distance 2′ 11′ in plan, Fig. 91, and place it on the line A B, as shown by 2′ 11′ of Fig. 92. At right angles to A B and from points 2′ and 11′ draw lines, making 11′ 11 and 2′ 2 equal respectively to *i* 11 and *b* 2 in elevation, Fig. 91. Draw a line from 2 to 11 in Fig. 92. Then will 2 11 be the actual distance on the finished article on the line 2′ 11′ in plan, Fig. 91. Proceed in precisely the same manner for the sections on dotted lines shown in Fig. 93. For example, take the distance 3′ 9′ in plan in Fig. 91 and place it in Fig. 93 on the line A B, as shown from 3′ to 9′. At right angles to A B from points 3′ and 9′ draw lines making 3′ 3 and 9′ 9 equal to *c* 3 and *g* 9 in elevation, Fig. 91. Then draw a line from 3 to 9 in Fig. 93, which will represent the true distance on the finished article on the lines 3′ 9′ in plan for 3 9 in elevation, Fig. 91.

For the pattern proceed as follows: Draw any horizontal line, as 1 12 in Fig. 94, equal to 1′ 12′ in plan, Fig. 91. Now with 12 11 in elevation as radius and 12 in Fig. 94 as center, describe the arc 11. Now with 1 as center and 1 11 of Fig. 93 as radius describe an arc in Fig. 94 intersecting the arc 11. Then with 1″ 2″ in the pattern, Fig. 91, as radius and 1 of Fig. 94 as center, describe the arc 2. Then with 11 as center and 11 2 of Fig. 92 as radius describe an arc in Fig. 94 intersecting the arc 2. Proceed in this manner, using alternately as radii first the divisions in the profile A B in elevation, Fig. 91, then the lengths of the dotted lines in Fig. 93, the intersected divisions in the pattern, Fig. 91, then the length of the solid lines in Fig. 92, the last division, 6 7 in pattern, Fig.

94, being obtained from 7′ 6′ or T U in plan Fig. 91. Trace a line through points thus obtained in Fig. 94. Then will 1 6 7 12 be the pattern for the sides of the bay, the miter cut 1 6 mitering with the cut A^1 D^1 in pattern, Fig. 91, while the cut 7 12 in Fig. 94 butts against the wall, indicated in elevation, Fig. 91, by A B.

SECTION IX

(Pages 1,013-1,038)

SHEET METAL BOAT PATTERNS

BOAT PATTERNS

TWO-PIECE SHEET METAL PRACTICE BOAT

It is not a very difficult job to make a boat shown in Fig. 1, and others can readily follow or modify this plan. To aid them the following description of the methods used for making a small boat of metal, without the use of patterns, and with no special machinery or models is presented for a light, fast boat—a little

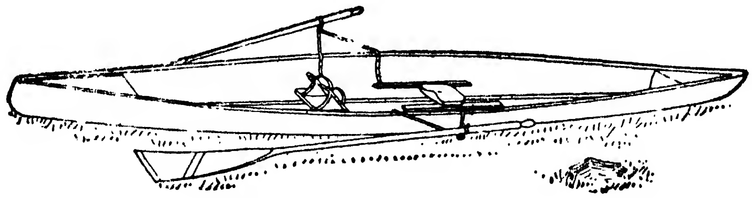


Fig. 1. General View of Boat

cranky, it is true—easily and cheaply made and adapted to either paddle or oars. This boat has proved perfectly safe in use, no defect in construction has appeared.

The present description will have nothing to do with pattern cutting, but will be the method followed in evolving the boat. To begin with, two sheets of No. 27 galvanized iron or steel, 30 inches wide and 96 inches long, should be marked and turned up in the cornice brake, as shown in Fig. 2. This forms the keel and at the same time provides the requisite stiffness for the bottom. Both sheets should

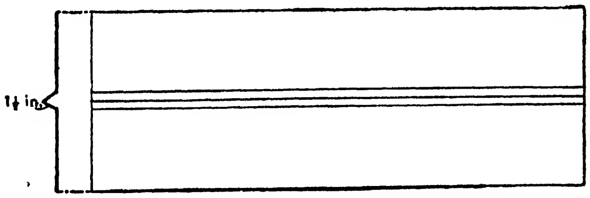


Fig. 2. The First Bend in the Hull Strips

now be formed up in the brake or over a large size pipe, to present the appearance of a trough, as shown in Fig. 3. In one end of each trough should be nailed a temporary wood brace about 1 x 4 inches, and of a length corresponding to the beam of the boat, which in this case is 19 inches.

At the end opposite the brace the curve of the trough should be straightened out, and the two sides brought together to form the prows. Each piece will then look like one-half of the boat, but with an exaggerated

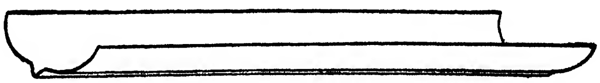


Fig. 3. Forming the Hull

sheer, and will present the appearance shown by Fig. 4. In this operation care should be taken that the work be done a little at a time on each side, so that the

keel may not be unduly strained, as it is very important that it should remain perfectly straight. At the end of the prow the V-shaped keel should also be drawn together, and both it and the curved sides gradually tapered out to the required size at the middle. The two ends of the prows may now be temporarily fastened together by means of $\frac{1}{2} \times 3$-16 inch stove bolts, and the corner at the bottom cut on a curve, as shown by dotted lines in Fig. 4.

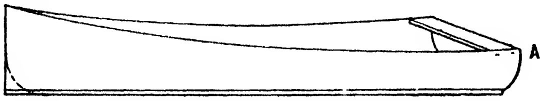


Fig. 4. Forming the Prow

Having determined the amount of sheer desired in the finished boat, the surplus metal should be cut away on a line marked for it. It should be remembered that the amount of sheer may be governed somewhat by the bevel of the sides of the boat at the top of the middle section. If the sides are perpendicular at the point marked A in Fig. 4 there would be no sheer in the finished boat, while the more the sides at that point are inclined outward the more sheer will be produced. In the present boat the sheer is only 2 inches—that is, the depth at the prow is but 2 inches more than the depth at the middle section. The sides of the boat may, therefore, be practically perpendicular.

Fig. 5. The Prow Piece

The metal at the prow should now have all the buckles hammered out, which may be done by using a smooth faced hammer on the inside and holding the square head on the outside, thereby stretching the metal. The prow ends may then be riveted together permanently. A piece of sheet iron should be cut the shape of the prow, as shown in Fig. 5, about 1 ¼ inches wide, and so placed that the outer edge should project about ¼ inch beyond the metal of the sides at the prow. Removing the temporary stove bolts, this piece should be riveted, together with the two thicknesses of the metal at the prow, with rivets ¾ inch apart, and the projecting edge of the separate piece clinched over the raw edges of the prow. The seam should then be thoroughly sweated with solder. The air chambers should extend about 28 inches back from the points of the prows, and should be air tight They are to prevent sinking should the boat fill with water. A piece cut the required size with 1-inch flanges, and extended as shown at C in Fig. 6 should be bent down at the dotted line A B. This forms the top and one end of the air chamber, and should be riveted to the sides of the boat, so that the top of the air chamber will be 1½ inches below the top of the boat. The extension C, Fig. 6,

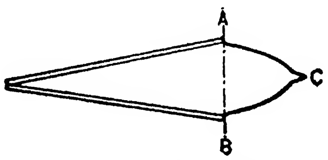
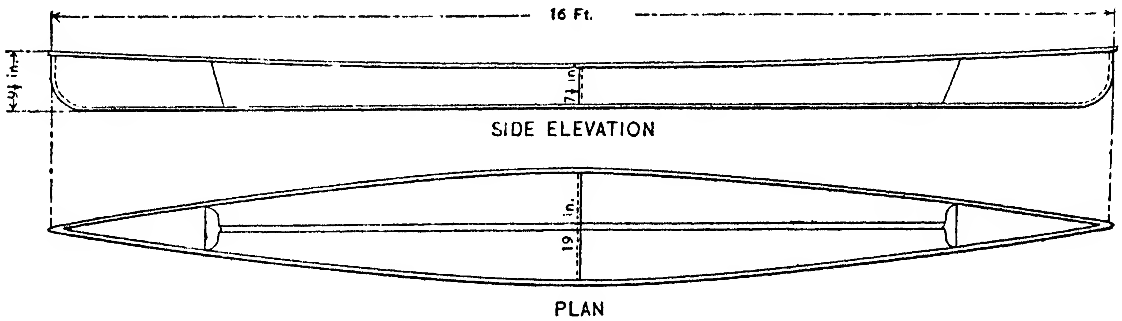


Fig. 6. The Top of the Air Chamber

should be long enough so that it fits snugly in place, inclined at an angle, and should be carefully soldered to the sides of the boat, instead of being riveted. When this is done, the two parts of the boat (which should be alike) may be fitted together at the middle.

Two boards with straight edges 1 inch apart should be nailed to a level floor. The keel may be set down in the groove thus formed and a level used on the wood braces. A few blocks nailed to the floor and marked at the hight of the sides will enable the boat to be removed from these primitive stocks and replaced exactly as before, without frequent recourse to the level and square. The two ends should be accurately fitted together with a lap of 1 inch and lightly tacked together with solder. The boat should then be turned over and a chalk line stretched along the



Fig, 7. Plan and Side Elevation of Two Parts Connected

keel. Any inaccuracies should be corrected, and the middle connecting seam securely riveted with rivets ¾ inch apart and soaked with solder inside and outside. The boat will then present the appearance shown in Fig. 7, which gives both the plan and side elevation with dimensions.

The topsides, or gunwale, is composed of two strips of white pine with the sheet iron between, and screwed together, with screws about 4 inches apart. The inner strip which is ⅜ × 1½ inches, receives the heads of the screws. The outer strip is ¾ × 1½ inches and is made thicker in order to more securely hold the tails of the screws, as shown at A in Fig. 8. The wood at the extreme end of the prows should be rounded at the points and bound with sheet copper fastened with small brass nails. To this copper may be soldered a small tube, in which may be inserted the staff of a small flag.

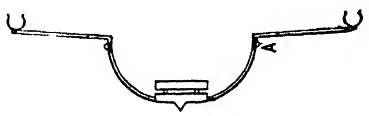
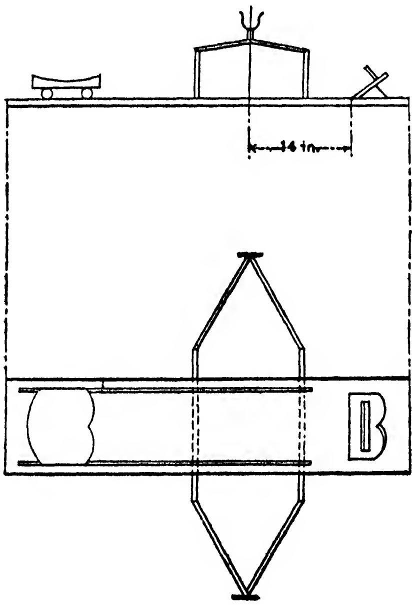


Fig. 8. Cross Section, Showing Gunwale Strip, Bottom Board and Oarlock Outriggers

The boat, or canoe, at this point weighs 35 pounds, and with a double bladed paddle forms a very satisfactory fast canoe for use in comparitively quiet waters. It may be painted to suit the individual taste. To transform it into a practice boat the seat and oars may be added. These are entirely separate from the shell. A white pine bottom board 1 foot wide, 4 feet long and 1¼ inches thick is shaved to fit the bottom of the shell near the middle section.

A pair of irons should be prepared by the blacksmith to fit loosely inside the shell at that point, and extend out over the sides 12 inches, joining together at the ends to receive the swivel oar locks, as shown in Figs. 8 and 9. These irons are ⅝ inch round where they overhang the water and are flattened on the inside of the boat. The under side of the bottom board is gouged out, so that the irons set in the wood, and the irons are securely bolted to the board, taking care that the bolts are countersunk, so that they do not scratch the shell of the boat. A foot rest with braces and toe straps should be securely screwed to one end of the board, and guiding strips for the seat rollers fastened in about the position shown in Fig. 8. Inside the guide pieces, where the wheels are to run, two strips of hard wood are inlaid to take the wear.



Fig, 9. Plan and Side Elevation of Seat and Outriggers

The roller seat should be gouged out of a piece of white pine about 7 inches square, and provided with rollers, which may be procured at any hardware store. It should be borne in mind that the lower the seat and rollers are placed the steadier the boat will be. With such a removable seat the position in the boat may be varied to suit, and as both ends of the boat are alike, the bottom board and seat may be reversed without necessitating the turning of the boat. Feathering spoon oars should preferably be used, although it takes a little practice to become accustomed to the proper turning of the wrist.

The cost of the material for the shell alone, including paint, should not be more than $2.50. The time and trouble will be more than repaid by the pleasure of one season's use. The keel, as shown, would be insufficient for an ordinary boat, but for such a boat it is ample, because the boat, when loaded, acts as a keel for itself. It may be added that on one occasion a man weighing 150 pounds

shipped so much water into the boat that it sank to a point where the water was half way between hip and shoulders, and the boat was then rowed ashore in the usual way, except that the boat itself was entirely under water.

CONSTRUCTING SHEET METAL BOATS ON SKELETON FRAMES

In shops doing this kind of work sheet metal boats are made in various sizes, for which there are kept on hand skeleton frames of wood, giving the length and beam of the boat and the various profiles throughout its entire length. These frames are used over and over again if a boat is required of that particular size, or,

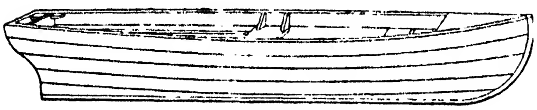


Fig. 1. General View of Boat

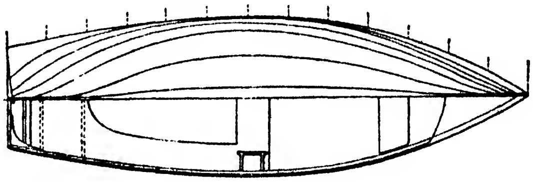


Fig. 2. Plan View

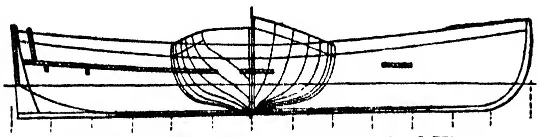


Fig. 3. Longitudinal Section and End View

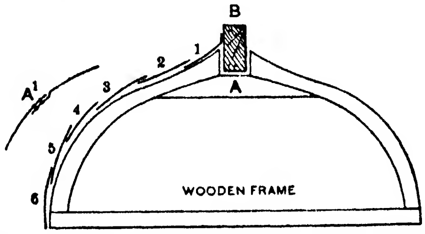


Fig. 4. Section of Skeleton Frame Made of Wood

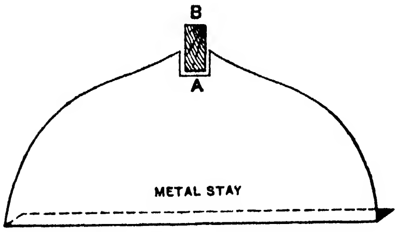


Fig. 5. Section of Metal Frame

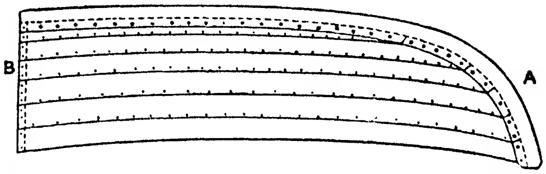


Fig. 6. Showing Gore Piece Flanged Out Against the Keel

PATTERNS FOR SHEET METAL BOATS

if a special size is needed, a new frame is made, and used as often as required. In this way the various shapes accumulate and are kept in stock.

If, however, it is desired to make but one boat for pleasure use, a skeleton frame work of metal stays is built up full size. First draw the plan view of the boat, as shown in Fig. 2; then draw and cut out of sheet metal the various shapes or sections, full size, as shown in the end views in Fig. 3. These stays should be

soldered in their proper positions on the plan of the boat as in Fig. 2, and braces placed between the stays to hold them in a vertical position. Now, whether the skeleton frame is made of wood, as shown by the section in Fig. 4, or of metal, as shown in Fig. 5, a notch must be cut at the top, as at A and A in Figs. 4 and 5, to receive the keel of the boat, B.

This keel is made of hardwood and covered with No. 22 galvanized iron, nailed with galvanized iron or brass nails, and the seams and nail heads thoroughly soaked with half and half solder, using 10-pound soldering coppers for same. The keel is then scraped well to obtain a smooth surface, when it is laid into the notches, as shown in Figs. 4 and 5. The keel being in position, the skeleton of the boat is placed upon a number of wooden horses or brackets, and the patterns for the gores are obtained. Space off on the stays of the frame the number of gores required; in this case six, as shown in Figs. 1 and 4. In other words, as each profile or stay varies in girth, each one must be divided into six equal spaces. From these spaces run a chalk line or soft, thin copper wire from stem to stern, being careful that the line touches each division on the stays. Then take some manila paper or very thin tin foil and place it over the lines drawn, when an accurate pattern is the result. These six gores, each being a different shape, are cut from No. 22 galvanized iron, allowing laps for riveting.

The metal work is now constructed over the skeleton frame, starting on the bottom at the keel, as shown by the gore piece 1 in Fig. 4. This gore piece is flanged out 1 inch against the keel, as shown in Fig. 6 from A to B, and nailed with galvanized iron or brass nails 1 inch long, and then thoroughly soaked with solder, using heavy roofing coppers. The first gore piece will require some stretching with the hammer to make it conform to shape desired, while the following gores 2 to 6 in Fig. 4, are formed up on a small roller similar to that shown in Fig. 7, C showing the section. When a large number of various size boats are made, various size male and female rollers are kept in stock, and placed in the standards A and B; and by means of the handle shown, the gores are fed through the rolls until the desired shape and radius are obtained. If a smaller or larger boat is being built, the rolls are taken out of the standards and the required rolls replaced. Where, however, but one boat is required the gores would have to be hammered up by hand, by using the required size raising hammer and a block of wood or part of the trunk of a tree about 12 inches diameter and 3 feet high, or on a block of lead. Assuming that this has been done, gores Nos. 2 and 3 in Fig. 4 are then placed in position, as shown in Fig. 8. By using a hand clamp the gore is tightly fastened against gore No. 2. But before putting gore 3 over gore 2 take a brush

with thick metallic paint and paint the entire seam of $1\frac{1}{2}$ inches on gore 2 or any other number. On top of the painted seam put a strip of asbestos paper about as thick as ordinary blotting paper, on top of which place gore 3. When riveting use 2-pound rivets, tinned, and be sure that the holes punched will be no smaller or larger than to just allow the rivet to fit snugly. Then rivet in a manner as shown in Fig. 9, always placing the top and bottom rivets between each other so close as to insure a tight joint. In this way all of the gores from 2 to 6 are fastened.

Where the gores are placed over sheet metal sections as in Fig. 5 some provision must be made for fastening the seams, as they cannot be fastened with the hand clamp. The seams can either be tacked temporarily with solder or wooden

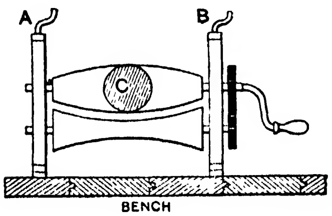


Fig. 7. Side View of Small Rollers

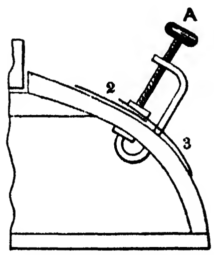


Fig. 8. Showing How the Gores Are Fastened in Position

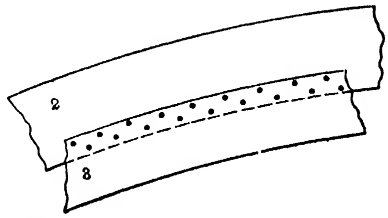


Fig. 9. Showing Manner of Riveting

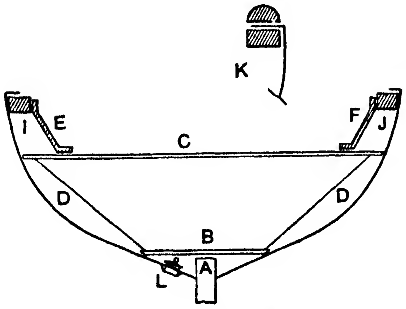


Fig. 10. Section Showing Manner of Fastening the Hard Wood Rail in Place

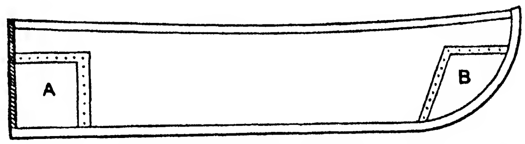


Fig. 11. Showing Position of Two Air Chambers

PATTERNS FOR SHEET METAL BOATS

lookouts put in place. After the gores are riveted water tight, then where each gore meets the stem and stern, as in Fig. 6, they are flanged so as to be nailed with galvanized or brass nails, and thoroughly soldered with heavy coppers, as at A and B. The stern of the boat at B is made of hard wood entirely covered on both sides with galvanized iron nailed and soldered in the same manner as described in connection with the keel. This, of course, is done before the gores are put in position.

The boat being finished thus far, the seams are set down so as to have a smooth surface on the outside, as shown at A^1 in Fig. 4, then the hardwood rail is placed at the top, as shown at I and J in Fig. 10, flanging the metal over the top as shown, over which a half bead is placed to make a smooth finish, allowing spaces for the row locks, as shown in K. In the bottom of the boat a tapped ferrule L, made of brass, is soldered, into which a threaded socket fits; then when the boat is in use and some water should accumulate in the bottom, it can be easily drained when the boat is not in use by unscrewing the socket, as is shown at L in Fig. 10. When the keel projects on the inner side of the boat, as at A, this forms the rest for the platform or foot rest B. C shows the seat resting upon the brackets D and D. Band iron braces E and F, galvanized and made of 3-16 × 1 inch band iron, are fastened to the rail and seat by means of wood screws as shown.

If desired, two air chambers can be put in the boat, one at the stem, the other at the stern as shown by A and B in Fig. 11, which will at the same time form a seat. These air chambers should be made of No. 20 galvanized iron, well riveted and soldered. A rudder can be placed at the stern by placing two eyes in the stern, onto which the rudder is hung by means of the two pins in same. In this connection it may be proper to say that if our correspondent desires the boat for his own use, and he can obtain a wooden boat which has passed its usefulness, he can strip off the outer covering, thus leaving the frame, which will be an excellent model on which to construct the metal boat.

BUILDING METAL BOATS BY MEANS OF MODELS

The first thing to do in the building of boats is to make a small model on a scale of 1 inch to the foot, of plaster of paris. To prepare this model, take a box of about the size of the proposed model and fill it with plaster of paris, mixed quite thin with water and stirred well. After it has settled take the box apart, dry the plaster thoroughly and carve out the model.

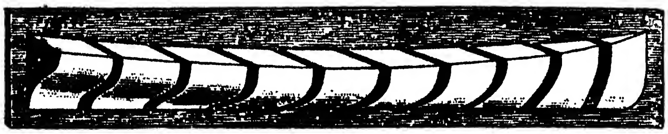


Fig. 1. Model Cut Into Sections

The next step is to cut the model into sections. This is done with a saw by cutting perpendicularly through the center from end to end and on a line with the keel. Take each half of the model and cut it across in sections 1½ inches long. Fig. 1 shows a sketch of a model cut up in this way. The next step is to take

each slice of the model and section it, as shown in Fig. 2 in reduced size, laying out the lines equal distances apart and at right angles to one another, making the squares about ¼ inch on a side. Now lay out the section full size, as shown reduced in Fig. 3, to correspond with the model. If the largest cross section in the

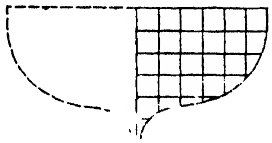


Fig. 2. Cross Sectioned Model. Reduced

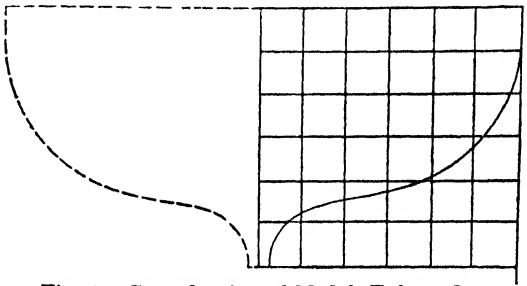


Fig. 3. Cross Section of Model, Enlarged

model is 4 inches, the plan should be laid out 4 feet, since the scale, as stated above, is 1 inch to the foot.

In the diagram, Fig. 3, the same number of spaces is laid off as on the model. Next trace the section line or profile through the spaces, which can be done by transferring the points where the profile of the model cuts the sections in Fig. 2 to corresponding points in Fig. 3. Repeat this operation with each of the sections shown in Fig. 1. After having a full sized profile of each section, cut them out of 1-inch boards. Set the boards or profiles 18 inches apart, or whatever distance is right to correspond with the scale of the model, and fasten these profiles firmly together. If the boat is a keel or round bottom boat, fit and fasten the keel at the proper place to the wooden stays. The keel can be made of iron or hardwood. Now draw horizontal lines on the edges of the stays or frames and these lines will be a gauge to which to cut the strips for the body of the boat.

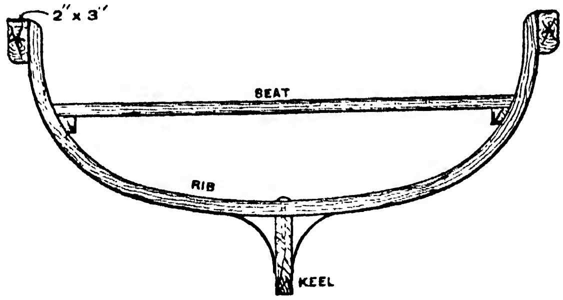


Fig. 4. Section Through Finished Boat

The easiest way to cut the strips is to lay the iron on the stays and mark out the strips to correspond with the lines. The width of the strips depends on the shape of the boat, and the builder must use his judgment in deciding what width to cut them to. Nail the strips to the stays and rivet them together between the stays. If the ends of the boat are pointed and it is impossible to get between the sides to rivet properly, take out the keel and cut the stays or frame in two from end to end and then rivet the ends. Then fasten the stays together again and

nail or rivet the keel to the iron. Take a strip of hardwood about 2×3 inches, or angle iron and fasten it around the top edge, and then put in the ribs, which can be of wood or light angle or tee iron, as preferred. The next operation is to take out the stays and solder the boat on the outside. A cross section through the boat is shown in Fig. 4. Make each end of the boat air tight and put water tight boxes under the seats, which will make a life boat of it, as the air compartments will prevent it sinking in case of filling with water. The first two coats of paint should be of red lead.

SHEET METAL CANOE

The following is a description of a sheet metal canoe: To begin with, it is made of six sections of No. 27 galvanized iron, 26 in. wide, straight and level on the bottom: It was made bottom side up, and was molded after the following

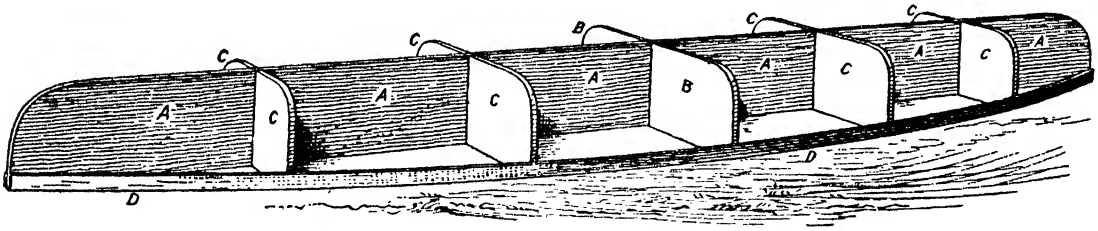


Fig. 5. Mold or Frame for Forming Canoe

fashion: A board 14 in. wide was taken of the desired length, in this case about 12 ft. long. This was fastened to the floor, and the shape resembled the sketch presented in Fig 5, in which A A., etc., shows the length and depth of board. The width of this board governs the depth of the boat, but the length can be varied to suit the material and desire of the maker. At the center of this long piece is connected two short pieces, B B, each half the width of the boat, and of the shape indicated, with one corner rounded to whatever circle best suits the ideas of the builder. For the outside edge of the bottom of the boat a 3-in. circle was used. After these pieces were nailed to the centerpiece, thin, narrow strips of elm, D D, were taken about ¾ in. thick and 1½ in. wide, long enough to spring around the short cross pieces B B, and were attached to the long centerpiece A A at each end. These pieces were bent so as to give the desired shape to the gunwale of the boat. The distance between the four other short cross pieces C C, on which and over which the sheet iron is formed, is governed by the width of the sheet iron used.

In this boat, 26-inch iron was used. When the pieces C C are securely fastened to A A and D D the mold for the canoe is ready for forming the sheet iron sections and riveting them together. If 26-inch iron is used it will allow for sections 25 in. long, after the laps are made. The shape of the finished canoe will be governed by the shape of the frame or mold. The bow and stern sections will have to be made in two pieces, with slits, as indicated at E, and made as designated in Fig. 6, to be covered by laps or patches to be riveted on and soldered. These slits aid in forming the bow and stern. The ends are also slitted or notched to aid in forming a strong, water tight joint at the bow and stern. When the mold is securely fastened together there is some advantage in having it so it can be lifted up and set on boxes, so as to avoid stooping to work on the floor It would be necessary to set the mold up if a canoe was being made with some shear.

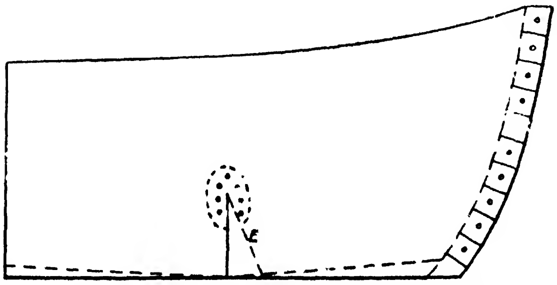


Fig. 6. Pattern of Bow and Stern Pieces

The work can best be started at one end, preferably the stern, to which the skeg is attached in the center and in line with the bow. The stern and stem pieces shown in Fig. 6 should be notched about 1 in. apart. The other side should be notched in the same way, but the two parts should be connected, so as to break the joints and alternate; the notched parts turned down so as to come even with the extending piece on the other sections, so that they can lap over on the section proper and be riveted in place, and finally soldered heavily by soaking. In order to give a little fullness to the canoe and a greater carrying capacity these end pieces should have a slit cut about midway of the section, so that one edge of the cut can be lapped over the other, and the part drawn until the straight line overlaps the oblique line shown at E, in Fig. 6, where it should be riveted in place. This will make a hole at the top of the gore, over which a patch must be riveted and soldered, as shown by the dotted lines. This will naturally throw the bottom line of the bow up a little, or out of a straight line with the bottom, and will necessitate its being trimmed so as to be on a straight line with the keel. A three-cornered bottom piece will be needed to connect with the side pieces, as the practical man will learn and supply.

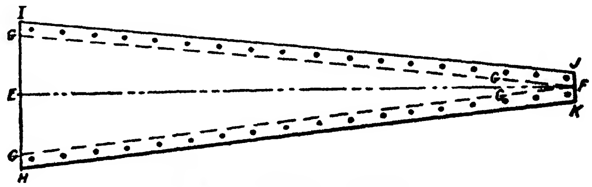


Fig. 7. Pattern of Skeg

1-lb. tinned rivets are used, placed $\frac{3}{4}$ in. apart, putting the heads on the outside always, and soldering all over the rivets well on both sides; also the seam. When the stern section has been snugly fitted temporarily to the first mold board C C, then the next section of sheet iron can be fitted, which is comparatively easy. When it is snugly fitted the next section is made, and finally the bow section completed. Care must be taken to fit each section snugly and true, and if this has been done all should be marked and the sections riveted together and soldered. When this is done the shell of the canoe is ready for reinforcement and the necessary fittings.

Good strips of elm or any other strong wood that will bend readily should be used for the gunwale to stiffen the canoe, and they should be made 2 in. wide and from $\frac{3}{4}$ to 1 in. thick. Fit these on the inside and nail into position with clout nails and clinch them on the inside. At the bow and stern fit in a piece or two of wood of proper shape to which fasten chest handles for carrying the canoe, hanging it up when not in use, and for attaching a line for mooring it. One can carry this canoe easily Indian fashion, bottom side up with the gunwales resting on his shoulders. After these end pieces have been put in, a brace should be put across the canoe about one-third the distance from each end, using $\frac{1}{2}$ in. iron pipe with a blank flange on each end drilled with screw holes for fastening to the gunwales. These braces, with the gunwales, keep the canoe from collapsing, the sheet iron being strong enough otherwise to hold the shape of the canoe without the need of ribs. This canoe is provided with outriggers for the purpose of rowing. For outriggers, 12-in. T hinges are used fastening the T part to the gunwale with stove bolts. The long or strap part of the hinge will then fold into the canoe out of the way when not in use. On the outer end of the strap are bolted U shaped pieces of iron strong enough for row-locks.

On the outside of the canoe at the stern, and in line with the keel and bow, a skeg should be fastened. The shape will be something like Fig. 7 before it is formed into a sharp V on the line E F, and the edges turned on the lines G G after holes are punched for riveting to the bottom of the stern piece. The skeg will be stronger if the V is not too close at the point of connection with the canoe bottom. The holes in the canoe bottom for the rivets are easiest made with a twist drill of the proper size, using the skeg for a template to insure the holes being in exactly the right place and to avoid forcing the skeg out of line. The rivets should be put in the holes H I J K first and the others afterward. It is easier to solder the skeg to the bottom in proper alignment and drill the holes afterward. The rivet heads should be on the outside of the canoe, thoroughly and smoothly

soldered. The skeg is about 30 in. long and $2\frac{1}{2}$ in. deep at the wide end. It should be made smooth at the point where it is attached to the canoe so as to avoid catching grass or anything to cause trouble. If attached on the proper line and made correctly it will greatly aid in keeping the canoe on a straight course when in motion.

Two cypress boards are fastened together and fitted to the bottom to support the seat box. There are no nails in these boards where they can scratch the metal or possibly wear a hole. The seat box is 26 in. long, 12 in. wide and 8 in. deep. It is covered with tin and soldered air-tight. This has two wire rings soldered on each side and is fastened by means of cord to staples in the wooden bottom. Although none were used it would perhaps be better to place air chambers in the ends.

BUILDING SHEET METAL BOATS FROM GORES OR STRIPS

With the constantly increasing scarcity of wood and the consequent advance in the price of lumber, there has been a growing tendency for a number of years to substitute other materials where formerly no one ever considered the use of anything but wood. The principal of these displacing materials are the iron and steel products, and accordingly sheet metal is used at the present time for a greater variety of purposes than ever before. One line in which its economy and practicability has been demonstrated for a number of years, and one in which it might be used to a greater extent, is in the building of small boats. As far back as 1850 a sheet metal boat known as the Francis Patent Metallic Life Car was used in life saving work off Squam Beach, N. J.

The accompanying illustrations will give an idea of the plans of constructing two sheet metal boats followed by two men after regular shop hours, one doing the metal work and his friend attending to the wood work. Each thus became the possessor of a boat at but a slight cost in cash paid out over the actual cost of the materials used.

As soon as the patterns were completed from sketches, work on the boats proper was started. They are 15 ft. long, 42 in. broad, 15 in. high in the center and 22 in. at the bow and stern. Each boat as shown has a sharp bow and the stern is pointed below the water line, flaring out as the top is approached until it is practically square. The keel is made of white oak $1\frac{1}{4}$ in. thick and $1\frac{1}{2}$ in. deep, and dressed. A triangular piece of wood $1\frac{1}{4}$ in. thick and about 3 ft. long was nailed on top of the keel at the stern to form the skeg, and also a support for the board which was used to form and reinforce the stern. The stem post was then fitted on to strengthen the bow. It is made of hardwood and forms an extension to the keel. Both the

bow post and the stern board are covered with metal of the same weight as the shell of the boat.

The shell is made from five pairs of gores or strips of metal cut from 8 ft. stock, with joints broken amidships. The first two gores, marked 5 in the drawings, one on each side of the keel, were flanged, so that they formed up against the side of the keel and lapped across the lower edge as shown in the cut. At the stern these strips were drawn up from the keel, leaving it bare and forming a covering for a portion of the skeg. Two sheets were then cut to extend from these strips down

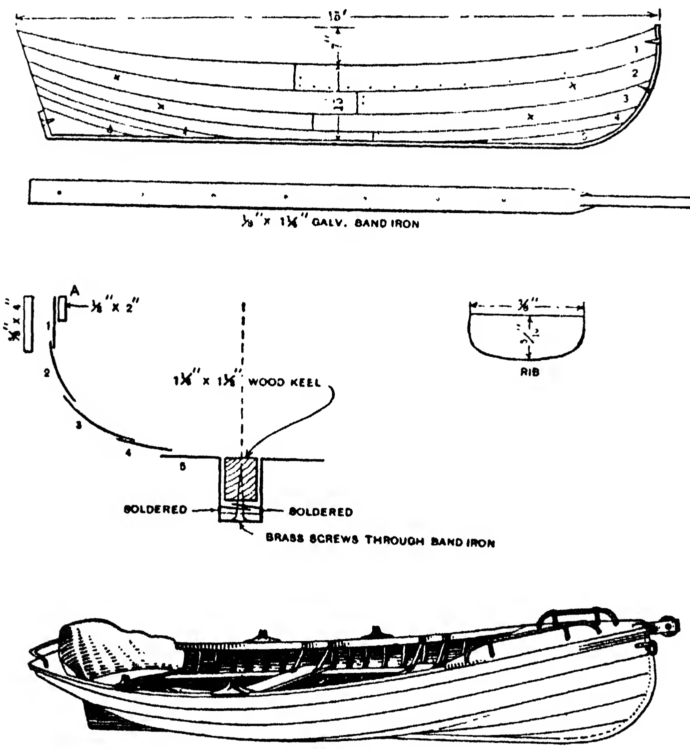


Fig. 1. A Sheet Metal Boat and its Various Parts

and lap under the keel. These sheets were then riveted through the skeg. A band of iron $1/8 \times 1\frac{1}{4}$ in. was laid on the under edge of the keel, lapping on to the rear of the skeg and fastened to it by brass screws $1\frac{1}{4}$ in. long, spaced a few inches apart and countersunk. At the bow this band is rounded and curves up to the bow post as a support. The seams between the metal strips and the iron band were soldered to make a water tight joint.

The keel was marked off into 5-in. spaces for the location of the ribs. The next pair of gores, 4, were cut and placed in position with practically no forming. Each strip was fastened to the lower one by tinned rivets, there being three in the space

between each pair of ribs. The next two pairs of strips had to be raised on a block with a raising hammer, on the first pair, the raising being commenced about 3 ft. from either end of the boat and on the next about 2 ft. from either end. The amount of the raising was determined by the eye and by trying, and did not take over two hours' labor for each boat. The fifth and last sections, No. 1, were then cut, and as in the previous cases riveted to the lower gores. As the different sections were put in place they were lapped around the bow post and riveted through and also through the stern board. Special care was taken to have the rivets neither too large nor too small for the holes, and they were staggered with the row on the gore below.

Ribs of elm 7/8 in. wide and 5-16 in. thick were placed in position on 5-in. centers and were fastened to each gore by a copper rivet and washer and nailed to the keel. These served to give ample stiffness to the boat. A strip of wood $5/8 \times 4$ in. was placed around the boat flush with the top on the outside, and a metal strip $1/8 \times 2$ in. on the inside to form the gunwale. A 1/2 in. bead was then placed around the upper edge, leaving spaces for the oar locks. A metal air chamber was constructed in each end, and afterward all seams soldered on the outside of the boat. A removable board was placed in the bottom to protect it and held in place by small clips on two longitudinal stays. Another longitudinal stay was next placed in position on each side to form a support for the seats, which were made from 1-in. lumber and braced by light iron strips. The ends of the boat were decked in and the stern seat put in place. By way of giving the boat a finished appearance, brass rails were put on the decks, and for convenience in hitching the boat a ring was attached to the bow. The boats were now ready to be painted. The first two coats consisted of red lead and the finishing coats to suit the taste of the owner. In constructing such boats, patterns may be dispensed with if the sheet metal worker can obtain some discarded wooden boat of the desired shape, or if such is not available and he does not desire to make his own patterns from scale drawings they can be purchased from companies in that line of business.

PATTERNS FOR A SHEET METAL BOAT DEVELOPED BY TRIANGULATION

To develop the patterns for the various gores in a sheet metal boat, when the seams run longitudinally proceed as follows: In laying out the patterns in Figs. 1 and 2, five gores have been used in the construction of the boat, so as to avoid a confusion of lines in so small a drawing. In practice, however, any number of gores can be used, applying the principles which will follow.

Let A B C D, Fig. 1, represent the side elevation of the boat. Establish where the extreme width of the boat shall be, in this case on the vertical line 9 57, and parallel to this line draw the center line E F at the left and E° F° at the right. Set off from these two center lines the half width of the keel, as shown at the left and right by *v* 57° and *v*° 57° respectively. In line with 9 57 in the side elevation draw the normal or given profile 9° *a* 57°, or as shown by P at the left and P° at the right. This given profile forms the basis, from which the various proportional vertical sections will be obtained. From *a* the widest part of the profile P, draw a horizontal line intersecting the line 9 57 in side elevation at *a*′. From A through *a*′ to D draw the dotted curved line, which will represent the extreme outer edge of the boat in elevation.

The drawing of the plan is now in order. Draw any horizontal line as G H, on either side of which place a duplicate of the half section P, as shown in plan by 9 *a* 57 on both sides. Project the line 9 57 in elevation and intersect it by horizontal lines drawn from *a* and *a* in the true section, thus obtaining *a* and *a*″ in plan. Extend the keel lines from 57 in the true sections and intersect them by lines projected from A, *b* and D in elevation as shown by *b* *b*′, A A^1 and D D^1 in plan respectively. From 9 and 9 in the true section, draw horizontal lines intersecting the line *a* *a*″ at 9 and 9″ respectively. Draw a graceful curve from A to 9 to D in plan, which will be the plan view of the boat when looking down on the line A D in elevation.

In a similar manner draw a graceful curve *b* *a* D in plan, which represents a horizontal view on the line *b* *a*′ D in elevation. Continue a graceful curve from D *a* in plan to A as shown by the dotted curved line *a* A. Then A *a* D shows a horizontal view of the extreme outline of the boat when viewed from the top, on the line A *a*′ D in elevation.

These lines A *a*′ D in elevation and A *a* D in plan are used for obtaining the extreme widths of the proportional sections. If desired, the lower half plan shown by *b*′ *a*″ D^1 and D^1 9″ A^1 can be duplicated from the upper half, although this is not necessary in the developments of the patterns. In this case we will assume that the boat is to be made in five gores, as shown by the profile P at the left, which has been divided into five parts as indicated by the heavy dots. Establish at pleasure where the gores are to turn upward and place this point in its proper position as indicated by 6 in the side elevation in Fig. 1, from which drop a vertical line intersecting the top edge of the boat in plan, also at 6. Divide the curve 6 A into as many spaces as the boat is to contain gores, five in this case, as shown by the heavy dots 6 to 1. At pleasure locate a series of planes through the left half

of the boat in the side elevation as shown by the planes 8 58, 7 59, 6 60, 6 61, 6 62 and 6 63, which will intersect the dotted curved line A *a'* in elevation at *c d e f i* and *k* respectively.

From these small letters *c* to *k* in elevation, project perpendicular lines into the plan, cutting the dotted curved line A *a*, also at *c d e f i* and *k* respectively. In a similar manner project 7 and 8 in elevation into the plan, and obtain the points 7 and 8 as shown.

The next step is to obtain the proportional vertical views on the various planes 9 to A in elevation. As the planes 8 58, 7 59, and 6 60 in side elevation stand in a vertical position, the sections which will be obtained on these planes will show their true shape.

From the points 8, 7 and 6; *c*, *d* and *e*; 58, 59 and 60, draw horizontal lines to the left until they meet the center line E F as shown. Measuring from the

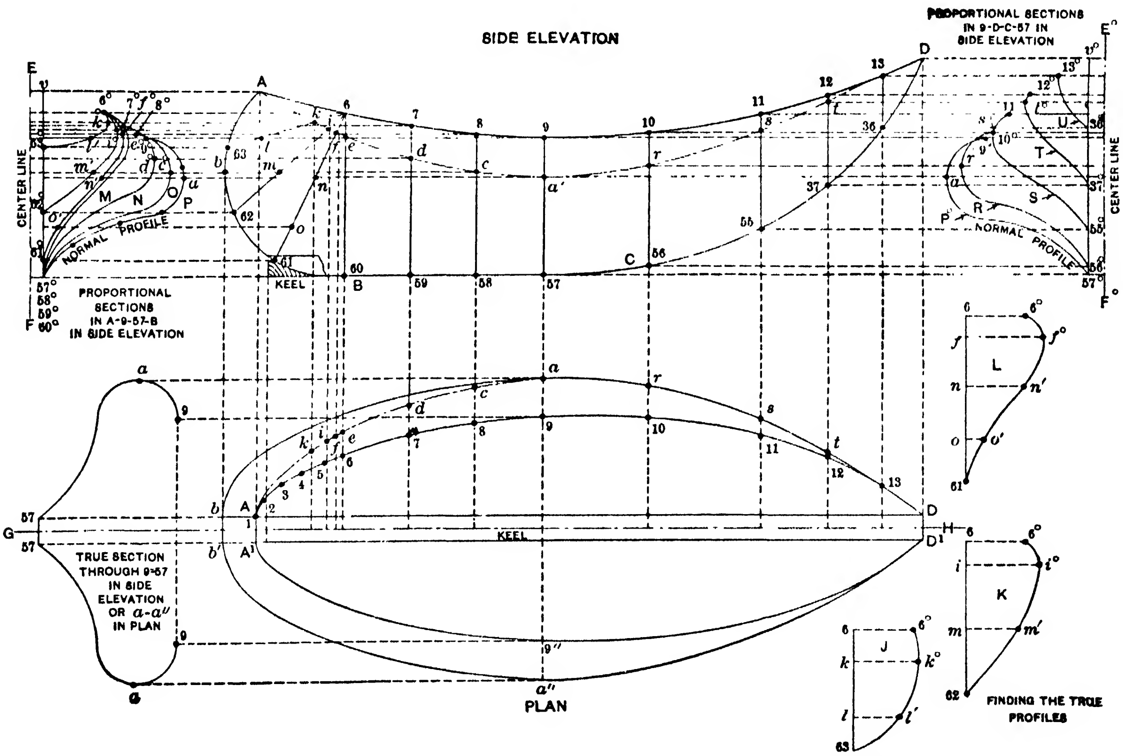


Fig. 1. Plan, Elevation and Method of Finding Proportional Vertical Section of Sheet Metal Boat

center line G H in plan take the projections to 8, 7 and 6; to *c d* and *e*, and place them on lines just drawn from similar letters and numbers in the side elevation, measuring in each instance from the line E F, thus obtaining the points of intersections 8°, 7° and 6°; *c*° *d*° and *e*° respectively. Through the points 8°, *c*°,

58° draw the profile O, giving it a proportional taper to the profile P. Through points 7°, *d*°, 59°, draw the profile N in proportion to the profile O. In a similar manner through the points 6°, *e*°, 60° draw the profile M, giving it a proportional taper to the profile N. These four profiles M, N, O, P, then represent the true sections on the planes drawn from 6, 7, 8 and 9 in the side elevation.

From the lower part of the planes at 61, 62 and 63 in the side elevation draw horizontal lines to the left until they intersect the keel line drawn from *v*, at 61°, 62° and 63°. From points *f*, *i* and *k* in the side elevation, draw horizontal lines to the left until they intersect the center line E F as shown. Measuring from the center line G H in plan take the distances to points *f*, *i* and *k* and place them on similar lettered lines just drawn from the side elevation, measuring from the line E F and obtaining the points *f*°, *i*° and *k*°. Through the points 6°, *f*°, and 61° draw a profile in proportion to the profile M, which will represent a vertical view on the plane 6 61 in the side elevation. In a similar manner through the points 6°, *i*°, 62° and 6°, *k*°, 63° draw graceful profiles in proportion to one another as shown. These last two profiles 6°, 62° and 6°, 63° represent the vertical views on the planes 6 62 and 6 63 in the side elevation.

The next step is to find the true sections on the planes 6 61, 6 62 and 6 63 in the side elevation, as follows: At pleasure establish any point as *l* on the plane 6 63; another at *m* on the plane 6 62, and two more at *n* and *o* on the plane 6 61. From these points *l*, *m*, *n* and *o*, draw horizontal lines to the left until they intersect the proper view, as indicated by *l*′, *m*′, *n*′ and *o*′. Take the various divisions on the planes in side elevation, as 6 *k l* 63, 6 *i m* 62, 6 *f n o* 61, and place them as shown by similar letters and numbers on the vertical lines to the right of the plan view, in the diagrams J, K and L respectively.

From the divisions on the vertical lines in J, K and L draw perpendicular lines indefinitely as shown. Measuring from the keel line *v* 57° in the sections to the left of the elevation, take the various distances to points 6° *f*° *n*′ *o*′ and place them on similar lines in diagram L measuring from the line 6 61, thus obtaining the points 6 *f*° *n*′ *o*′. Through the points trace a graceful profile as shown, which will represent the true section on 6 61 in the side elevation.

In a similar manner, measuring from the keel line *v* 57°, take the distances to points 6° *i*° *m*′, also to 6° *k*° *l*′, and place them on similar lettered and numbered lines in the diagrams K and J respectively, thus obtaining the points of intersection shown by similar letters and numbers. Draw the profile from 6° to 62 and from 6° to 63, which will represent respectively the true sections on the planes 6 62 and 6 63 in the side elevation.

These planes which are shown drawn through points 10, 11, 12 and 13 in the side elevation cannot be drawn at pleasure, but must be located in a manner which will be described as we proceed. To avoid a confusion of lines which would otherwise take place in so small a space, take a tracing of the side elevation of the boat A B C D, with the various planes 9 57, 8 58, 7 59, 6 60, 6 61, 6 62 and 6 63, and place it as shown by A^x B^x C^x D^x in the side elevation in Fig. 2, also reproducing the planes just mentioned as shown by similar numbers.

In a similar manner reproduce the half plan b a D A in Fig. 1 as shown by b^x a^x 14′ 1′ in Fig. 2, placing it in line with the elevation as shown. Take a tracing of the divisions from 1 to 9 in the plan in Fig. 1 and place them in a similar position in the half plan in Fig. 2, as shown from 1′ to 9′. Take tracings of the true profiles J, K, L, M, N, O, P, in Fig. 1, and place them as shown by J° K° L° M° N° O° and P° in Fig. 2.

As the boat in this case is to contain five gores, divide the sections J°, K° and L° each into five equal spaces, as shown from 6° to 63, 6° to 62 and 6° to 61 respectively. From these points perpendicular to the vertical lines, draw lines intersecting the vertical line at 25, 26, 46, 47 in J°; at 24, 27, 45, 48 in K°, and at 23, 28, 44 and 49 in L°. Take the various divisions on 6 63 in J°, 6 62 in K° and 6 61 in L° and place them on similar numbered planes in the side elevation, thus obtaining similar numbered intersections as shown by the heavy dots. From the intersections 1′ to 6′ in the half plan, project lines into the elevation, cutting the top line of the boat from 1 to 6 as shown.

In the true sections, P° represents the given profile, which is also divided into five equal spaces as shown, from which points lines are drawn perpendicular to 9 57, intersecting this line at 19, 32, 40 and 53. Take these divisions on 9 57 in P° and place them as shown by similar numbers on the plane 9 57 in the side elevation.

Through the various intersections on the planes 6 1, 6 63, 6 62, 6 61 and 9 57 in the side elevation, draw graceful free-hand curves, representing the longitudinal joints as follows: From 5 through 25, 24, 23, 19 to 14, which gives the elevation of A or the first gore; from 2 through 47, 48, 49, 53, then continue with a graceful curve until it meets the bow at 55, which gives the elevation of the fifth gore E. Divide this distance between 55 and 14 into as many parts as the boat is to have gores, minus the first and last gore. As the boat in this case is to have five gores, then the space between 55 and 14 is divided into three parts as shown by 36 and 37.

Complete the other two longitudinal joint lines by drawing graceful sweeps

from 4 through 26, 27, 28, 32 to 36; from 3 through 46, 45, 44, 40 to 37. Thus the drawing of these last two joint lines gives the elevation of the second gore B, the third gore C and the fourth gore D. Where these joint lines intersect the bow of the boat at 36, 37 and 55, this gives the location from which the vertical planes are erected as 36 13, 37 12 and 55 11.

Establish another point between 11 and 9 as 10, and draw the vertical plane 10 56. By following the points of intersections in the side elevation, it will be found that they have been numbered starting at 1 to 14, to 25, to 26, to 36, to 37, to 46, to 47, to 55, to 56, to 63.

Where the longitudinal joint lines cut the planes 6 60, 7 59 and 8 58 at from 22 to 50, 21 to 51, and 20 to 52 respectively, take the various divisions on 6 60,

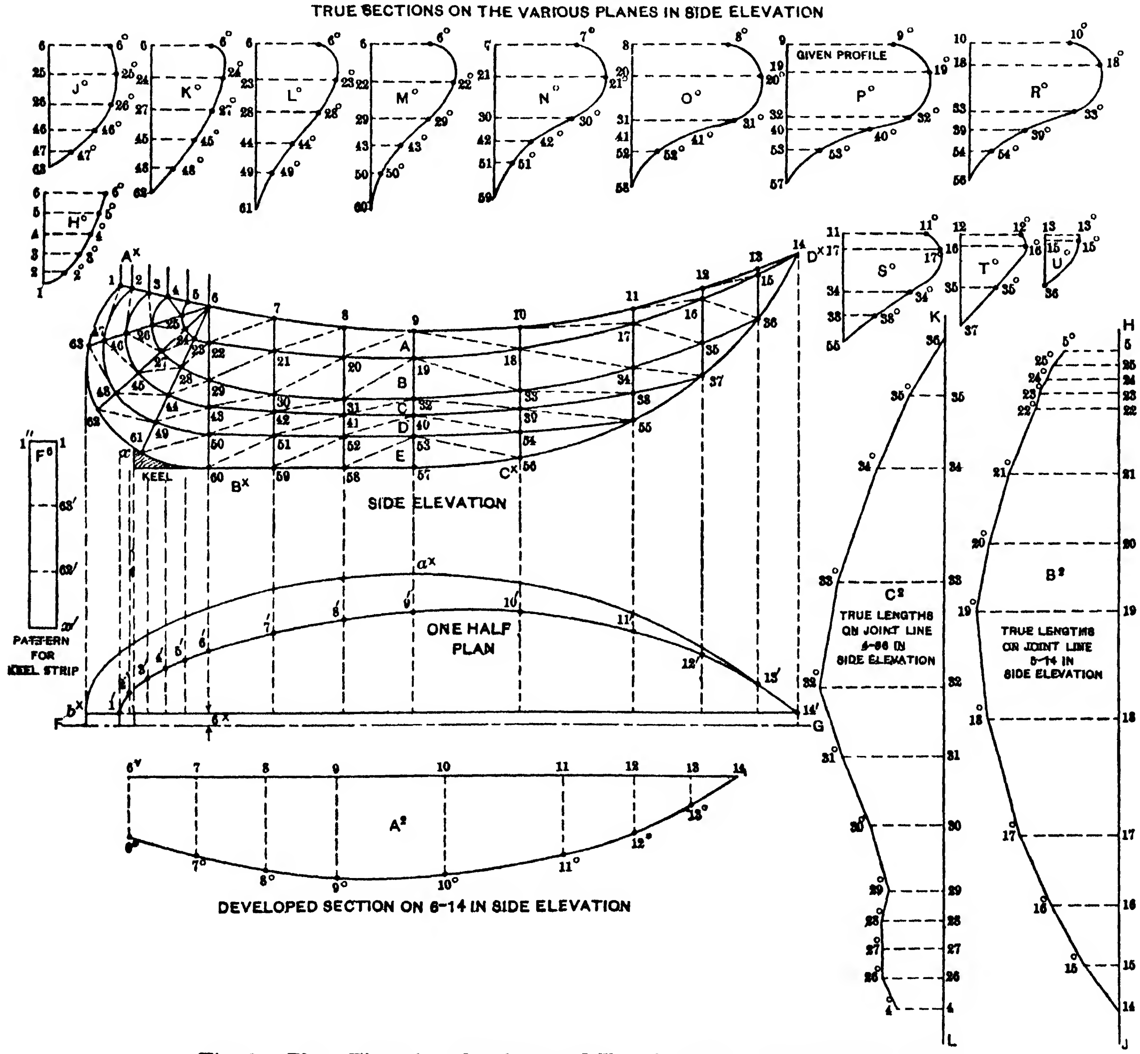


Fig. 2. Plan, Elevation, Sections and True Lengths of Sheet Metal Boats

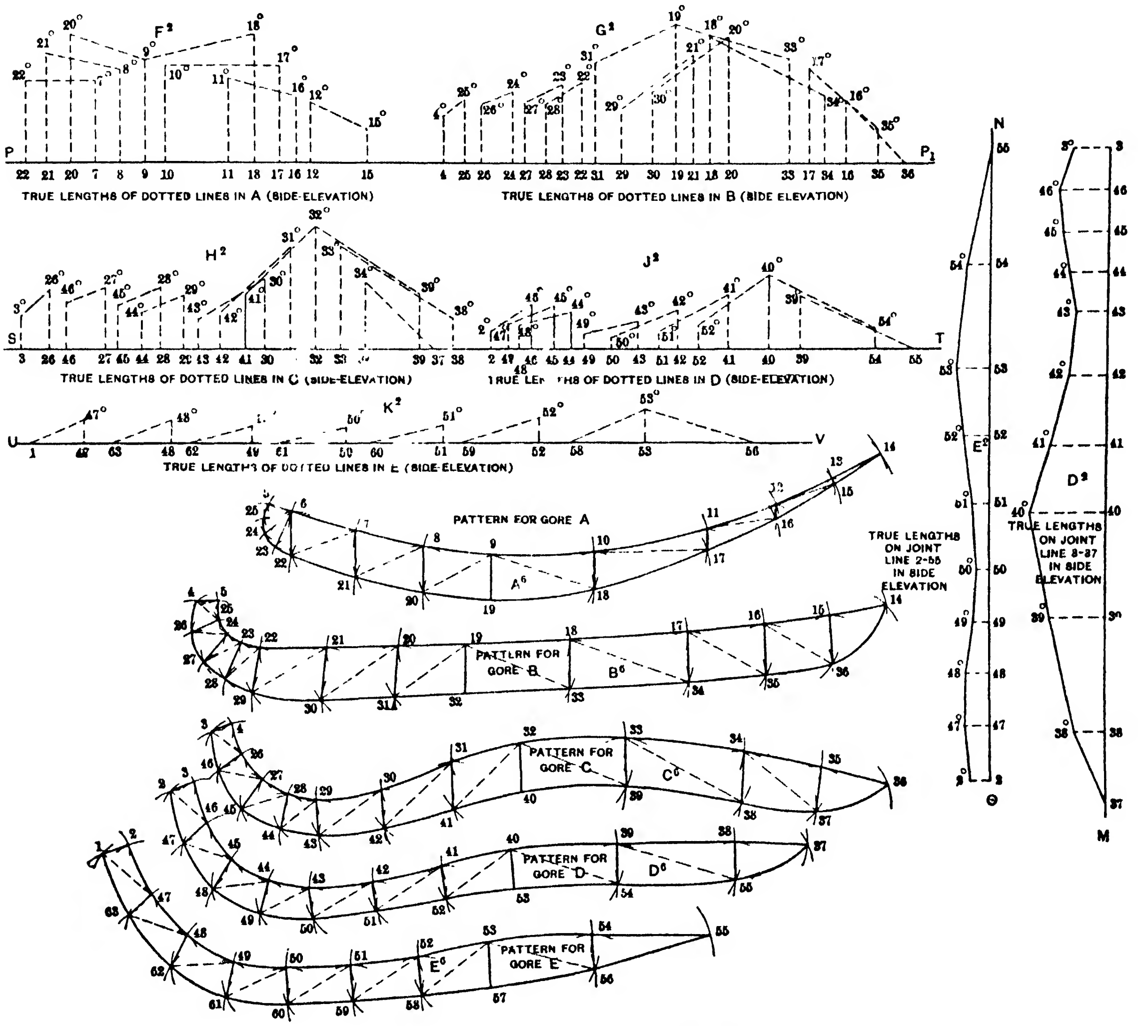


Fig. 2. True Lengths, Sections and Pattern Shapes of Sheet Metal Boats

7 59 and 8 58 and place them on similar numbered lines in the true sections as shown by similar numbered intersections on the vertical lines 6 60, 7 59 and 8 58 in the profiles M°, N° and O°. From these intersections on the vertical lines draw lines at right angles to 6 60, intersecting the profile M° at 22°, 29°, 43° and 50°, which divisions will give the proper girth when laying out the patterns. In a similar manner at right angles to the vertical lines in N° and O° from the various intersections on same, lines are erected until they cut the profiles as shown.

It now becomes necessary to find the true sections on the planes 10 56, 11 55, 12 37 and 13 36 in the side elevation as follows : Take a tracing of these

various planes in 9 D^x 57 in the side elevation and place them as shown by similar numbers in the half elevation 9 D 57 in Fig. 1, noting where the planes cross the extreme outer edge of the boat at *r*, *s* and *t*. Extend the planes into the plan, so as to obtain similar intersections 10, 11, 12 and 13 for the top edge of the boat, and *r*, *s* and *t* for the outer extreme edge of the boat. The various intersections in elevation give the hights of the profiles to be found, while the various intersections in plan will give the projections.

To find the proportional true sections on the planes 10 56, 11 55, 12 37 and 13 36 proceed as follows: From the intersections 36, 37, 55 and 56 in the side elevation draw horizontal lines to the right, intersecting the keel line v° 57° at 36°, 37°, 55° and 56° respectively. In a similar manner from the intersections 10, *r*, 11, *s*, 12, *t* and 13 in the side elevation, draw horizontal lines until they intersect the center line E° F° as shown by similar numbers. Measuring from the line G H in plan take the various projections to points 10, *r*, 11, *s*, 12, *t* and 13 and place them on lines drawn from similar numbers in the elevation, measuring in each instance from the center line E° F°, and obtaining the points of intersections 10°, r°, 11°, s°, 12°, t° and 13°.

Through the intersections 10°, r°, 56° draw the profile R in tapering proportion to the profile P°. Through the points 11°, s°, 55° draw the profile S in proportion to the profile R. In a similar manner through points 12°, t°, 37° draw the profile T in proportion to S, and through points 13° 36° the profile U in proportion to T. Then will the profiles R, S, T and U represent the true sections through the planes 10 56, 11 55, 12 37 and 13 36 respectively in the side elevation.

Take a duplicate of the profile R, S, T and U and place them in Fig. 2 as shown by R°, S°, T° and U°. Now take the various intersections on the plane 10 56 in the side elevation and place them on the vertical line 10 56 in the true section R°. At right angles to 10 56 from the intersections 18, 33, 39, 54 draw lines cutting the profile as shown by similar numbers. In a similar manner transfer the intersections from the planes 11 55, 12 37 and 13 36 in the side elevation, on to similar numbered vertical lines in the true sections S°, T° and U° and obtain the intersections on the outlines of the profiles as shown.

Thus it will be noted that only the true sections J°, K°, L° and the given section or profile P° have been equally spaced; all the spaces on the balance of the true sections are unequal. This becomes necessary, so that graceful sweeps can be obtained along the longitudinal joints in the side elevation. Thus if all the true sections were divided into equal spaces, and these divisions projected to the vertical

line in the section, thence to the corresponding plane in elevation, the joint line would become zig-zag, owing to the changing of each profile on the planes in elevation.

Connect by dotted lines the shortest opposite points in the side elevation as from 22 to 7, 21 to 8, 20 to 9, etc., as shown. These solid and dotted lines in elevation then represent the bases of sections which must now be constructed, whose altitudes are equal to the various hights shown by similar numbers in the various true sections. The true lengths on the various planes in elevation are shown by similar numbers in the true sections.

To find the true length of the upper edge line of the boat shown from 1 to 6 in the elevation, take the girth from 1 to 6 and place it as shown on the vertical line in H°. Through these small figures perpendicular to 6 1 draw lines making them equal in length to the distances measured from the line b^x 6^x in plan to points 1′ to 6′. A line traced through points thus obtained in H° as shown from 2° to 6° will be the true length of the upper line of the boat from 1 to 6 in elevation.

Next, to find the true length of the upper line 6 14, take this girth and place it on the horizontal line 6^v 14 below the plan as shown by similar numbers, through which at right angles to 6^v 14, draw lines indefinitely as shown. Measuring from the line 6^x 14′ in plan take the various divisions to points 6′ to 13′ and place them on similar numbered lines in A^2, measuring in each instance from 6^v 14, thus obtaining the points of intersections 6° to 13°. A line traced through these points will give the true lengths along the upper edge of the boat 6 14 in elevation, and this developed section on 6 14 in the side elevation, will be known hereafter as A^2.

To obtain the true length of the joint line 5 14 in side elevation, take the various divisions 5 to 25, to 24, to 23, etc., up to 14 and place them on any vertical line as H J as shown by similar numbers. Through these numbers at right angles to H J draw lines as shown, making them equal in length to the various hights in the true sections having similar numbers, measuring always from the vertical lines in the various sections.

For example, to find the true length of 18 19 in the side elevation, place this distance on the line H J as shown from 18 to 19, from which points erect the perpendicular 18 18° and 19 19° equal respectively to the distances 18 18° in the true section R° and 19 19° in the true section P°. Then a line drawn from 18° to 19° in B^2 will be the true length desired. In this way, all of the true lengths in B^2 are obtained.

Take the various divisions on the joint line 4 36 in the side elevation and place them on the vertical line K L, from which points lines are erected equal in length to similar numbered hights in the true sections. As no two sections are numbered alike, no mistake can occur in finding the proper distance to be placed in C^2 in which the solid irregular line shows the true lengths of the various divisions required. In a similar manner take the girth of the various spaces in the joint lines 3 37 and 2 55 in the side elevation and place them on the vertical lines J M and N O respectively as shown by similar numbers. From these small figures, perpendiculars are drawn, equal to similar numbered distances in the proper true sections or profiles, thus giving the true lengths in diagrams D^2 and E^2.

In the side elevation, the various gores have been lettered A B C D and E. To find the true lengths of the dotted lines in A, take the various lengths of 7 22, 8 21, 9 20, etc., and place them on any line as P P_1 as shown by similar numbers in F^2, setting each inside of one another, to save space. From these small figures on P P_1 in F^2, erect perpendiculars equal to the various projections of similar numbered points in the true sections. Thus to find the true length of 8 21 in the gore A in side elevation, take this distance and set it off on the line P P_1 as shown by 8 21. From 8 and 21 erect the perpendiculars 8 8° and 21 21° equal to similar numbers in the true sections A^2 and N°. The distance from 8° to 21° in F^2 then gives the true length of the line 8 21 in gore A in side elevation.

In a similar manner take the lengths of the various dotted lines in gore B in side elevation, also placing them upon the line P P_1 and obtain the true lengths of these lines as indicated in diagram G^2. In precisely the same manner take the various lengths of the dotted lines in gores C, D and E in the side elevation and place them as shown by similar numbers on the lines S T and U V respectively, making the vertical hights in these three diagrams H^2, J^2 and K^2 equal to similar hights in the various true sections. As before mentioned, no mistake can occur in finding these true lengths as every point has a different number.

No true lengths need be found along the bottom of the boat 1 57 14, as this line shows its true length. The true sections having been found, also the various true lengths on all points shown in the side elevation, the various patterns are now in order, and we will begin with the gore A in the side elevation starting at 5 6.

Take the distance of 6° 5° in the true section H°, and place it as shown by 6 5 in the pattern shape A^6. Using 6 as center and 6° 25° in the section J°, 6° 24° in the section K°, 6° 23° in the section L° and 6° 22° in the section M° as radii, draw the various arcs in the pattern A^6 as shown by 25, 24, 23 and 22. Using 5 as

center and 5° 25° in the true lengths in B^2 as radius, intersect the arc 25 in A^6 as shown. Again using the divisions in B^2 from 25° to 24°, 24° to 23° and 23° to 22°, set them off in the pattern A^6, as shown by the intersections 25 to 24, 24 to 23 and 23 to 22. Draw lines from 22, 23, 24 and 25 to 6.

With 6° 7° in the developed section A^2 as radius, and 6 in the pattern A^6 as center, describe the arc 7, which intersect by an arc struck from 22 as center, and 22° 7° in the true lengths in F^2 as radius. Now with 22° 21° in the diagram B^2 as radius, and 22 in the pattern A^6 as center, describe the arc 21, which intersect by an arc, struck from 7 as center, and 7° 21° in the true section N° as radius. Proceed in this manner, using alternately first the proper division in A^2, then the true length in the diagram F^2; the proper division in B^2, then the proper length shown along the profile in the true section, until the intersection 14 in the pattern A^6 has been obtained, which completes the pattern for the gore A in side elevation.

The pattern for gore B is shown by B^6. The spaces along 5 14 are obtained from the spaces along 5 14 in the lower part of the pattern A^6. The length of the dotted lines in B^6 are obtained from the true lengths in G^2, while the length of the solid lines in B^6 are obtained from the curved parts of the various true sections of similar numbers. The divisions along the lower edge in the pattern B^6 are taken from the true lengths in C^2, excepting the distance 36 14 in the pattern B^6, which is taken from 36 14 in the side elevation which shows its true length.

The pattern for the gore C is shown by C^6. The divisions along the upper edge are taken from the lower edge of B^6, the divisions along the lower edge in C^6 are obtained from the true lengths in D^2, excepting 36 37 in C^6, which is taken from the side elevation. The length of the solid and dotted lines in C^6 are taken respectively from the curved profiles in the true sections and the true lengths in diagram H^2. So in D^6, which represents the pattern for the gore D, the divisions along the upper edge line are obtained from the divisions in the lower edge line in pattern C^6. The divisions along the lower edge in D^6, being obtained from the true lengths in E^2, excepting the division 37 55 in D^6, which is obtained from similar numbers in the side elevation. The lengths of the solid and dotted lines in the pattern D^6 are taken respectively from the divisions in the curved profiles in the true sections having similar numbers and the true lengths in the diagram J^2.

The last pattern against the keel, shown in side elevation by E, is shown developed by E^6. The divisions along the upper edge line are obtained from the divisions in the lower edge line in the pattern D^6 while the divisions along the lower edge line of the pattern E^6 are obtained from the lower line of the boat in the side elevation which shows its true length along the keel, as shown by similar

numbers. The lengths of the various solid and dotted lines in the pattern E^6 are obtained respectively from the proper numbered divisions in the curved profiles in the true sections and the slant lines in diagram K^2.

The pattern for the keel strip, following the continuation of the wooden keel, is simply a rectangular piece of metal shown in the diagram F^6 and is developed as follows: Take the girth from 1 to 63 to 62 to x in the side elevation, and place it as shown by similar numbers in F^6, making the width I 1″ as wide as the width of the wooden keel, or twice the width of 6^x in the one-half plan. This completes all of the patterns, to which laps must be allowed for nailing to the wooden keel, as well as for riveting the overlapping longitudinal joints.

The various gores must be raised or stretched to conform to the various true sections shown. When raising the various gores, the various true full-size sections should be cut out, flanges allowed and nailed on the proper plane line in the full-size side elevation placed on the floor. This then gives a model, after which the various gores can be fitted and then riveted and the joints and rivets sweated with solder. The seats at each end of the boat should be made up in the form of an air-tight compartment, to keep the boat from sinking if overturned.

SECTION X

(Pages 1,039-1,090)

GEOMETRICAL PROBLEMS AND MENSURATION

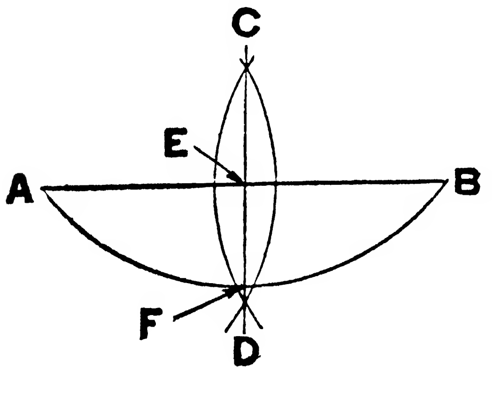
Geometrical Problems

Geometrical Problems.—The following problems illustrating how various geometrical figures are constructed, are to be solved by the use of pencil, dividers, compasses, and scale.

Many of these problems are such as are encountered in sheet metal work in laying out patterns. Proficiency in the solution of these problems will be of value to draughtsmen.

***Problem 1.**—To bisect or divide into two equal parts a straight line or arc of a circle.*

In fig. 132, from the ends AB, as centers, describe arcs cutting each other at C and D, and draw CD, which cuts the line at E, or the arc at F.



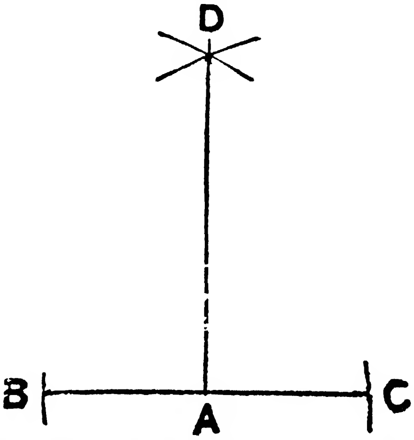


FIG. 132.—***Problems 1 and 2.*** *To bisect a straight line or arc of a circle and to erect a perpendicular to the line which is a radial line to the arc.*

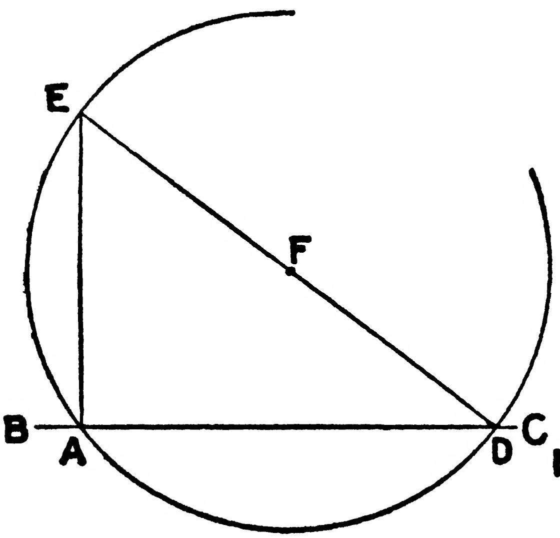
FIG. 133.—***Problem 3*** *To erect a perpendicular to a straight line, from a given point in that line,*

Problem 2.—To draw a perpendicular to a straight line, or a radial line to an arc.

In fig. 132 the line CD is perpendicular to AB, moreover, the line CD, is radial to the arc AFB.

Problem 3.—To erect a perpendicular to a straight line, from a given point in that line.

In fig. 133 with any radius from any given point A, in the line BC, describe arcs cutting the line at B and C. Next, with a longer radius describe arcs with B and C, as centers, intersecting at D, and draw the perpendicular DA.



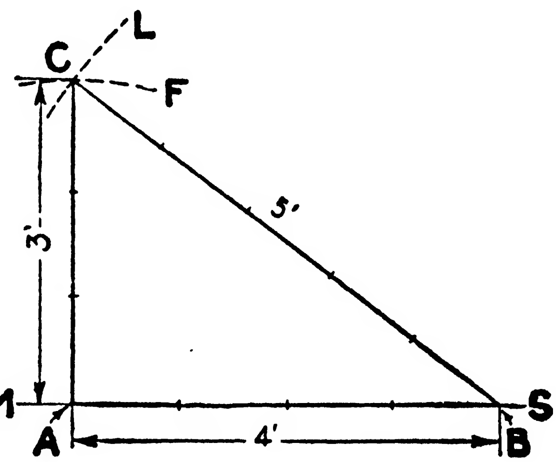


FIG. 134.—*Problem 3. Second method.*

FIG. 135.—*Problem 3. Third method (boat builder's laying down method).*

Second method. In fig. 134 from any center F, above BC describe a circle passing through the given point A, and cutting the given line at D; draw DF, and produce it to cut the circle at E; now draw the perpendicular AE.

Third method (boat builders' laying down method)—In fig. 135 let MS be the given line and A, the given point. From A, measure off a distance AB, say 4 ft. With centers A and B, and radii of 3 and 5 ft. respectively, describe arcs F and L, intersecting at C. Draw a line through A and C which will be the perpendicular required.

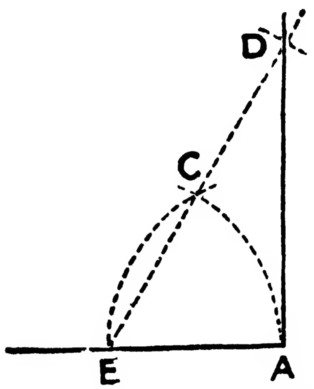
Fourth method.— In fig. 136, from A, describe an arc EC, and from E, with the same radius, the arc AC, cutting the other at C; through C, draw

a line ECD, and set off CD, equal to CE, and through D, draw the perpendicular AD.

***Problem 4.**—To erect a perpendicular to a straight line from any point without the line.*

In fig. 137, from the point A, with a sufficient radius, cut the given line at F and G; and from these points describe arcs cutting at E. Place triangle on points A and E, and from A, draw perpendicular to line GF

Second method.—In fig. 138, from any two points, B,C, at some distance apart, on the given line, and with the radii BA, CA, respectively, describe arcs cutting at A and D. Place triangle on points A and D, and draw the perpendicular AD.



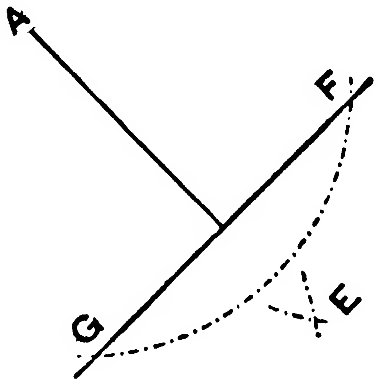
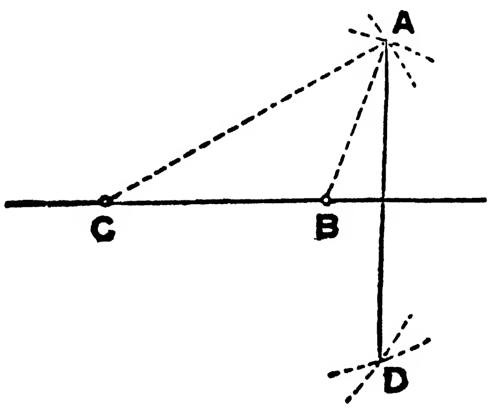


FIG. 136.—***Problem 3.** Fourth method.*

FIG. 137.—***Problem 4.** To erect a perpendicular to a straight line, from any point without the line.* If there be no room below the line, the intersection may be taken above the line, that is to say, between the line and the given point.



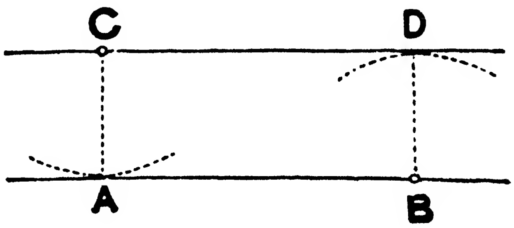


FIG. 138.—***Problem 4.** Second method.*

FIG. 139.—***Problem 5.** Through a given point to draw a line parallel with a given line.*

***Problem 5.**-Through a given point to draw a line parallel with a given line.*

In fig. 139, with C, as center describe an arc tangent to the given line AB; the radius will then equal distance from given point to the given line. Take a point B, on line remote from C, and with same radius, describe an arc. Draw a line through C, tangent to this arc and it will be parallel to the given line AB.

Second method.– In fig. 140, from A, the given point, describe the arc FD, cutting the given line at F; from F, with the same radius, describe the arc EA, and set off FD, equal to EA. Draw the parallel through the points AD.

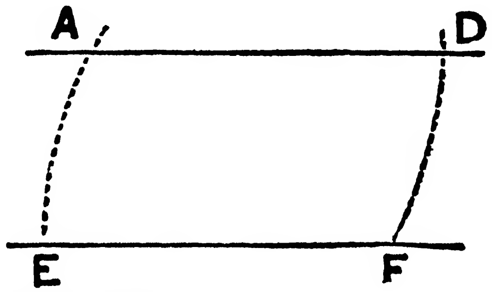


FIG. 140.—***Problem 5.** Second method.*

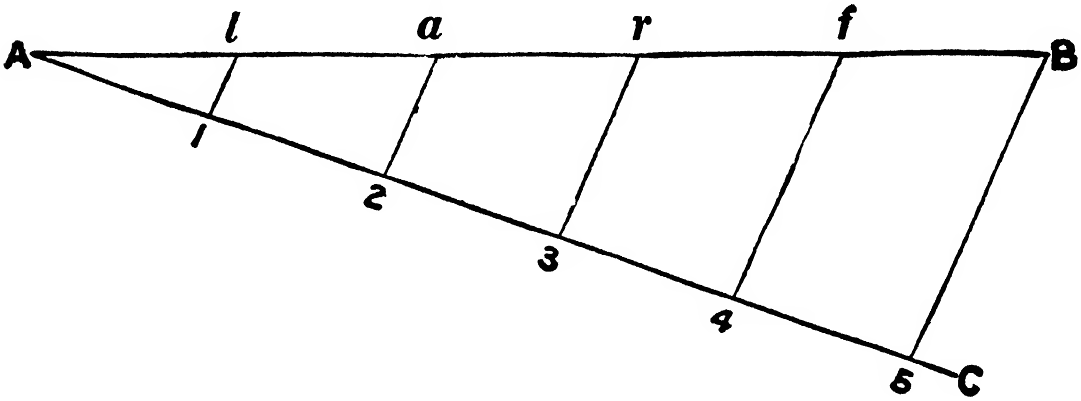


FIG. 141.—***Problem 6.** To divide a line into a number of equal parts.*

***Problem 6.**—To divide a line into a number of equal parts.*

In fig. 141 assuming line AB, is to be divided into say 5 parts, draw a diagonal line AC, and space off 5 unit lengths. Join B5, and through the points 1,2,3,4, draw lines 1*l*, 2*a*, etc., parallel to B5, then will AB, be divided into five equal parts, A*l*, *la*, *ar*, *rf*, and *f*B.

***Problem 7.**—Upon a straight line to draw an angle equal to a given angle.*

In figs. 143 and 144 let A, be the given angle and FG, the line.

With any radius from the points A and F, describe arcs DE, and IH, cutting the sides of the angle A, and the line FG.

Set off the arc IH, equal to DE, and draw FH. The angle F, is equal to angle A, as required.

***Problem 8.**—To bisect an angle.*

In fig. 145, let ACB, be the angle; with center C, describe an arc

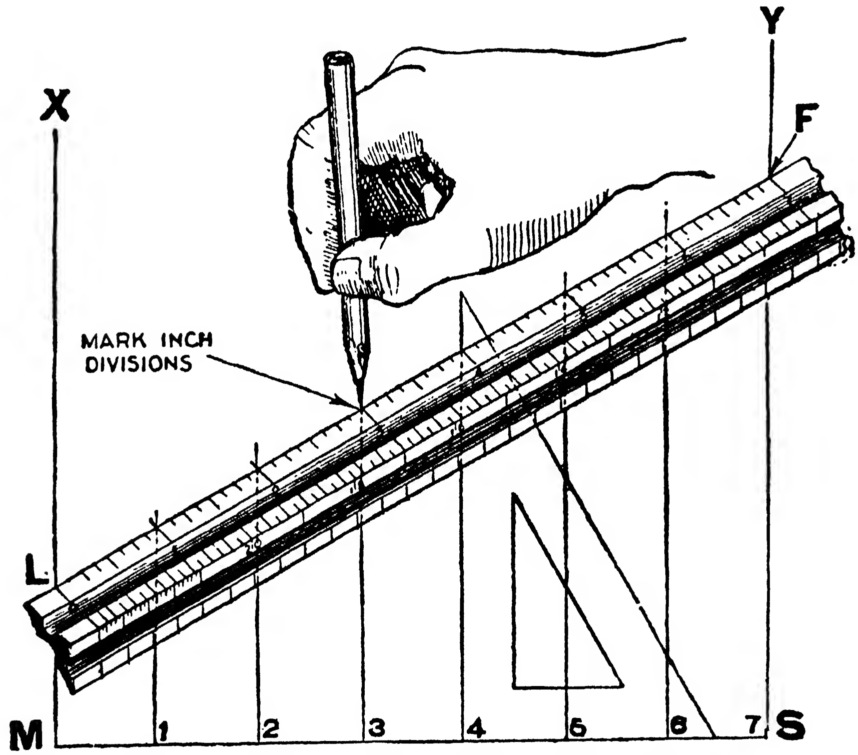
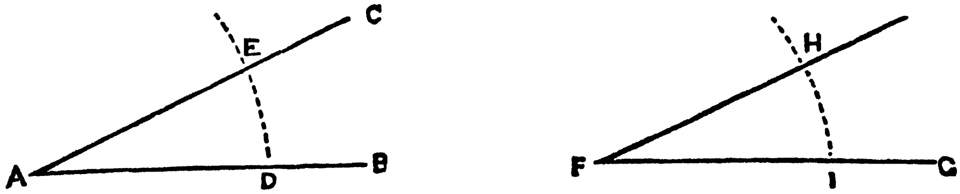


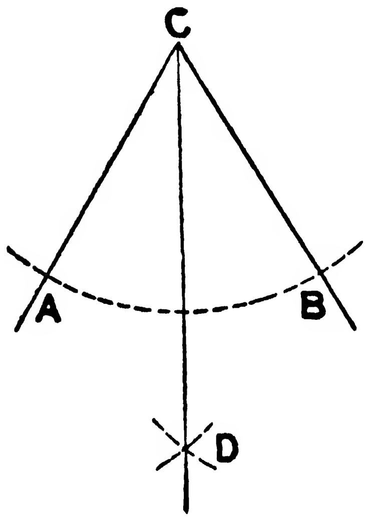
FIG. 142.—To divide a given line into any number of equal parts without dividers. Let M S, be the line and say it is to be divided into seven equal parts. Erect perpendiculars M X and S Y. Lay the O, mark of the scale on the line M X, and place scale at such angle that coincides with line S Y. Draw a light line L F, and mark the inch divisions as shown. With a triangle and T square draw lines from the points on L F, to M S, cutting M S, at 1, 2, 3, etc., which divide M S, into seven equal parts.



FIGS. 143 and 144.—*Problem 7. Upon a straight line to draw an angle equal to a given angle.*

cutting the sides at A and B. On A and B, as centers describe arcs cutting at D. A line through C and D will divide the angle into two equal parts.

Problem 9.—To find the center of a circle



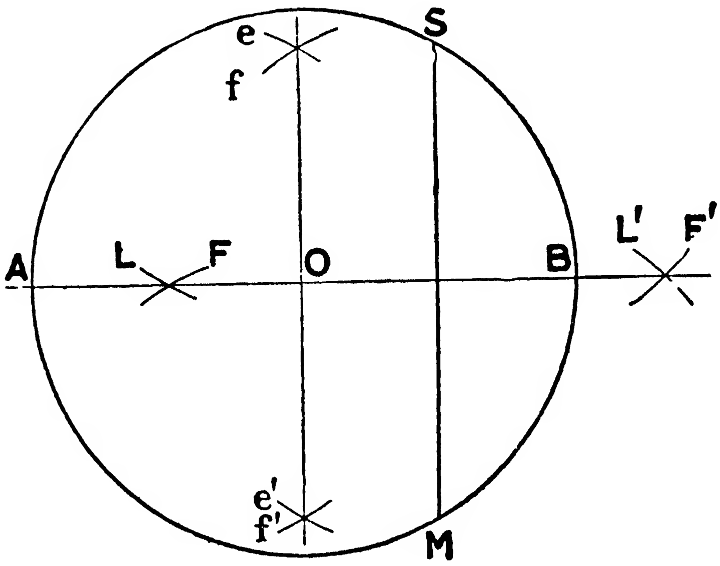
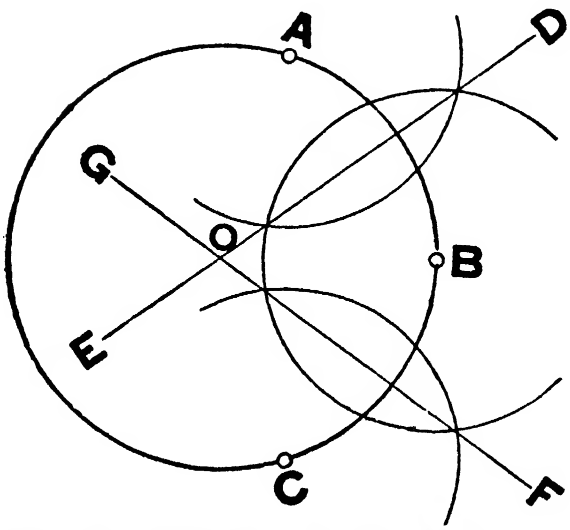


FIG. 145.—***Problem 8.*** *To bisect an angle.*
FIG. 146.—***Problem 9.*** *To find the center of a circle.*



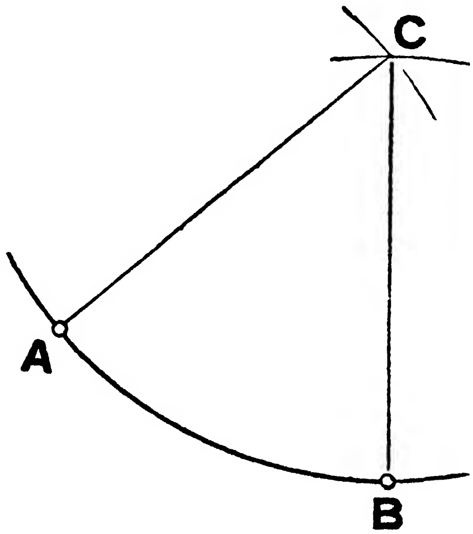


FIG. 147.—***Problem 9.*** *Second method.*
FIG. 147.—***Problem 10.*** *To describe a circle passing through three given points.*
FIG. 148.—***Problem 11.*** *Through two given points to describe an arc of a circle with a given radius.*

In fig. 146, draw any chord as MS. With M and S, as centers and any radius, describe arcs L,F, and L′,F′, and a line through their intersection, giving a diameter AB. Applying same construction with centers A and B, describe arcs *ef*, and *e′ f′*. A line drawn through the intersections of these arcs will cut AB, at O, the center of the circle.

Problem 9.*—Second method.* To find the center of a circle.

In fig. 147, select three points. A,B,C, in the circumference, well apart: with the same radius describe arcs from these three points cutting each other, and draw two lines DE, FG through their intersections. The point O, where they cut is the center of the circle or arc.

Problem 10.*—To describe a circle passing through three given points.*

In fig. 147, let A,B,C, be the given points and proceed as in last problem to find the center O, from which the circle may be described. This problem

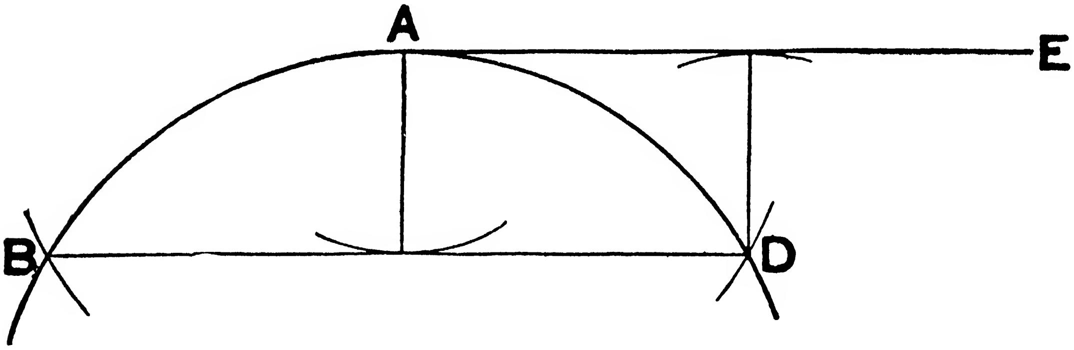


FIG. 149.—***Problem 12.*** *To draw a tangent to a circle from a given point in the circumference.*

is useful in such work as laying out objects of large diameter as an arch, when the span and rise are given.

Problem 11.*—Through two given points to describe an arc of a circle with a given radius.*

In fig. 148, take the given points A and B, as centers, and, with the given radius, describe arcs cutting at C; from C, with the same radius, describe the required arc AB.

Problem 12.*—To draw a tangent to a circle from a given point in the circumference.*

In fig. 149 from point A set off equal segments AB, AD; join BD, and draw AE, parallel with it, for the tangent.

Problem 13.—On a given straight line A5, to construct any regular polygon say a pentagon.

In fig. 150 produce the given side A5, say to the left. With center A, and radius A5, describe a semi-circle. Divide the semi-circle into as many equal parts as the polygon is to have sides; in this case 5 equal parts, by trial with

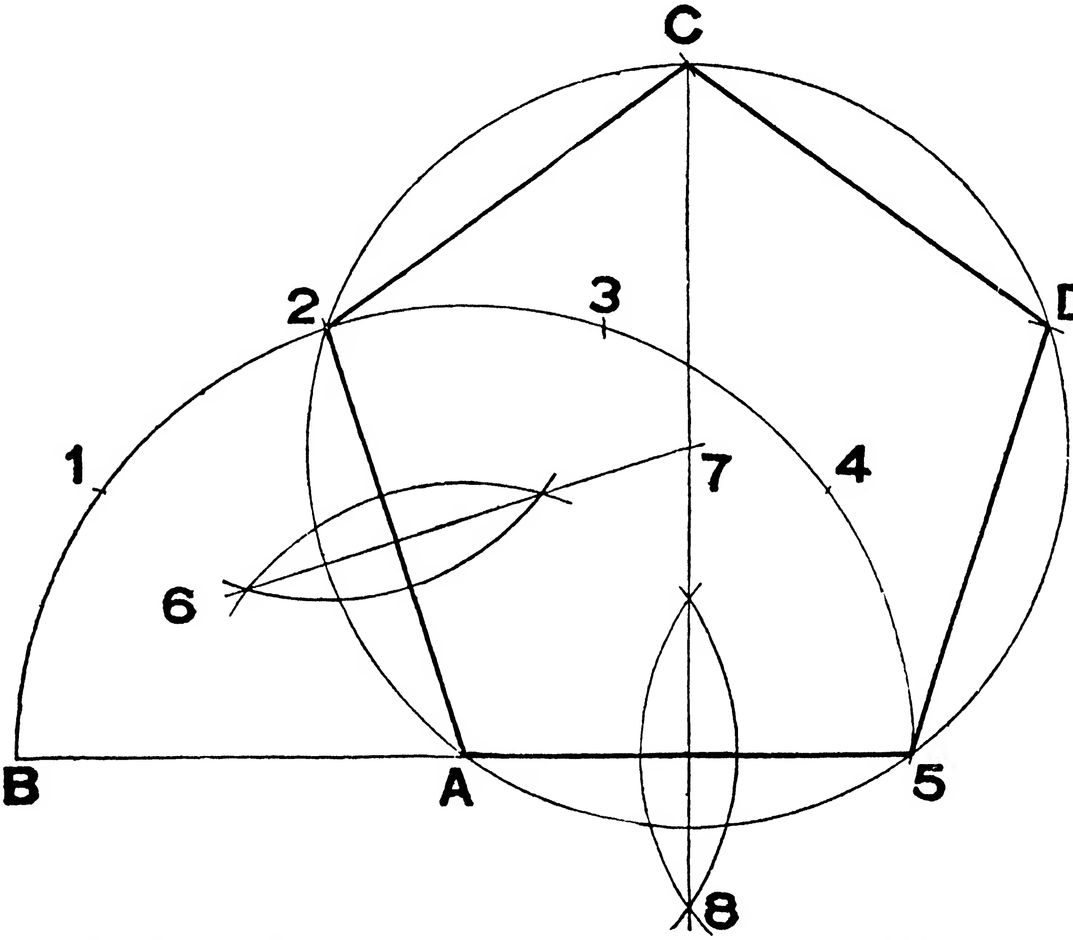


FIG. 150.—*Problem 13. On a given straight line, to construct a regular polygon.*

compasses. From A, draw A2, which gives another side of the polygon; and no matter how many sides the polygon is to have, always draw from A, to the second division on the semi-circle. Bisect the sides 2 A, A 5, by lines 6 7, and 8 7, intersecting at point 7, which is the center of the polygon. With center 7, and radius 7 A, describe the circle. Mark off, on the circumference, the divisions 2C, CD, equal to A5. Joint 2C, CD, D5. Then A2CD5, is the required regular polygon.

Problem 14.—To ascertain approximately, the length of the circumference of a given circle.

In fig. 151, draw a diameter AB. Find center C. Draw AD, perpendicular to AB, and 3 times the length of the radius. Draw BE, perpendicular to AB. With 30° triangle, draw angle BCH = 30°. Mark joint J, on BE. Join J D. Then line J D, is (approximately) equal to half the circumference; and twice J D = the whole circumference. This method is sufficiently accurate for all practical work, because the result is wrong only by about a $\frac{1}{100{,}000}$

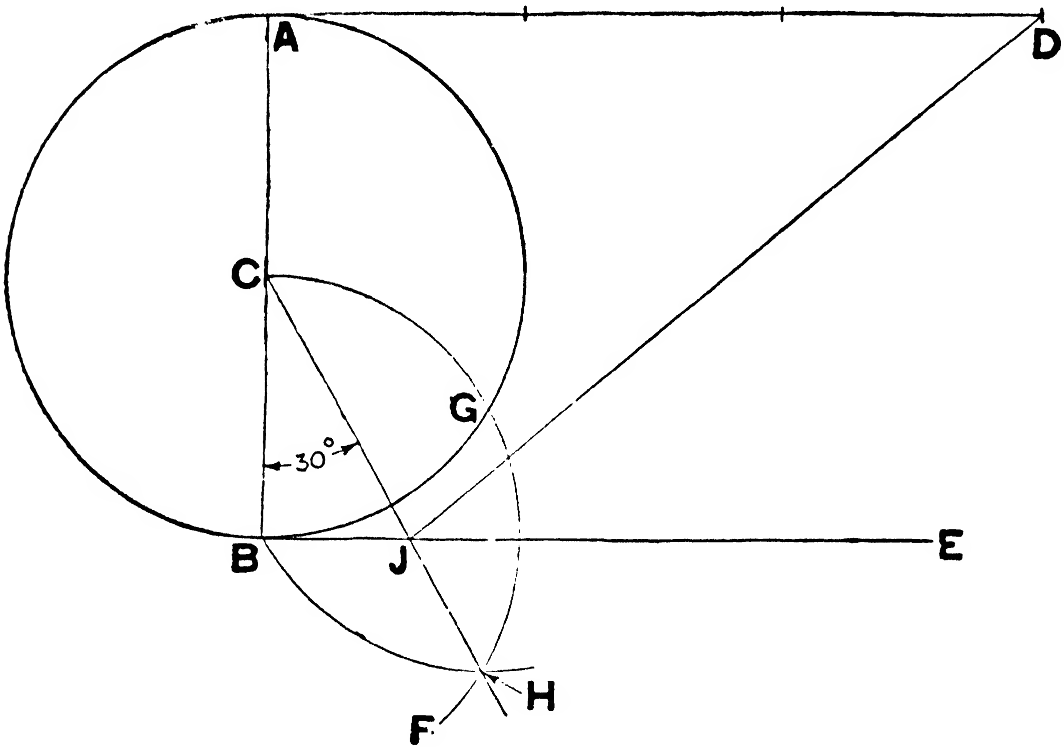


FIG. 151.—*Problem 14. To ascertain approximately, the length of the circumference of a given circle.*

part. This problem helps to ascertain approximately, the length of certain portions of the circumference. Thus ⅓ of JD = ⅙ of the circumference. Archimedes demonstrated that the diameter is to the circumference, within a minute fraction, as 7 is to 22, or 1 to $3^1/_7$. Thus, for all practical purposes, it may be assumed that if the diameter = 1 in., the circumference = $3^1/_7$ ins. To describe a circle having a circumference equal to the circumferences of any number of given equal or unequal circles: *Draw a line equal to the sum of the diameters of the given circles. This line is the diameter of the required circle.*

***Problem 15.**—To find the center of a given circle, or arc of a circle.*

In fig. 152, draw any two chords, 12 and 23. Bisect these chords by perpendiculars 45, and 67, intersecting at A. Point A, is the center of the circle or arc. The chords are not obliged to meet at 2. They may be drawn anywhere in the circle or arc, but it is better, when possible, to let them be at about right angles to each other. The chords may intersect. They should not be made too short.

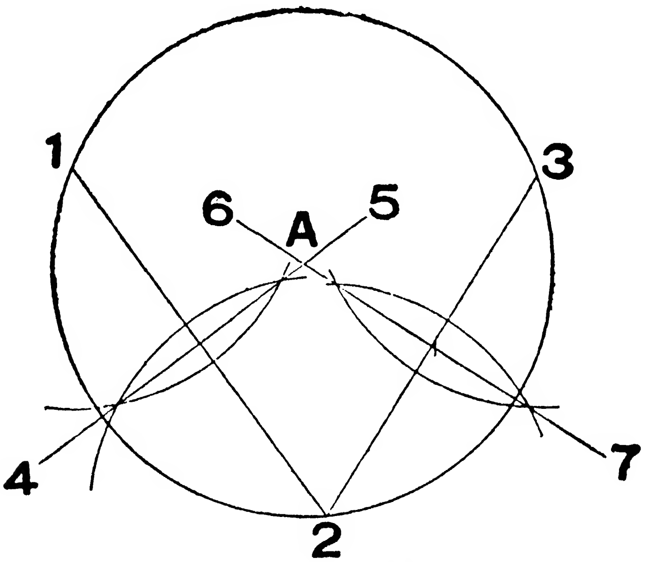


FIG. 152.—*Problem 15. To find the center of a given circle, or arc of a circle.*

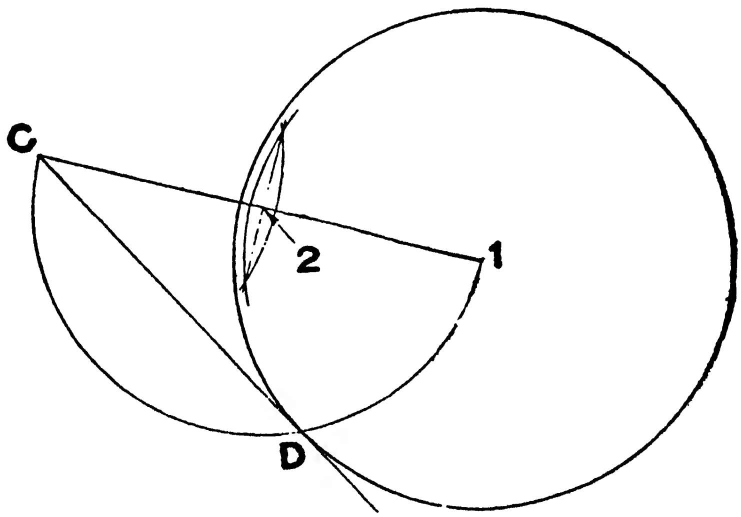


FIG. 153.—*Problem 16. To draw a tangent to a given circle from any given point.*

***Problem 16.**—To draw a tangent to a given circle from any given point C, outside the circle.*

In fig. 153, 1 is the center of the given circle. Join points C1. Bisect C1, at 2; and with center 2, and radius 2 C, or 21, describe a semi-circle, cutting the circle at D. Point D, is the point of contact. Through D, draw CD, which is the required tangent.

CD, is tangent because a line through the point of contact D, and center 1, of the circle makes a right angle with CD. Why?

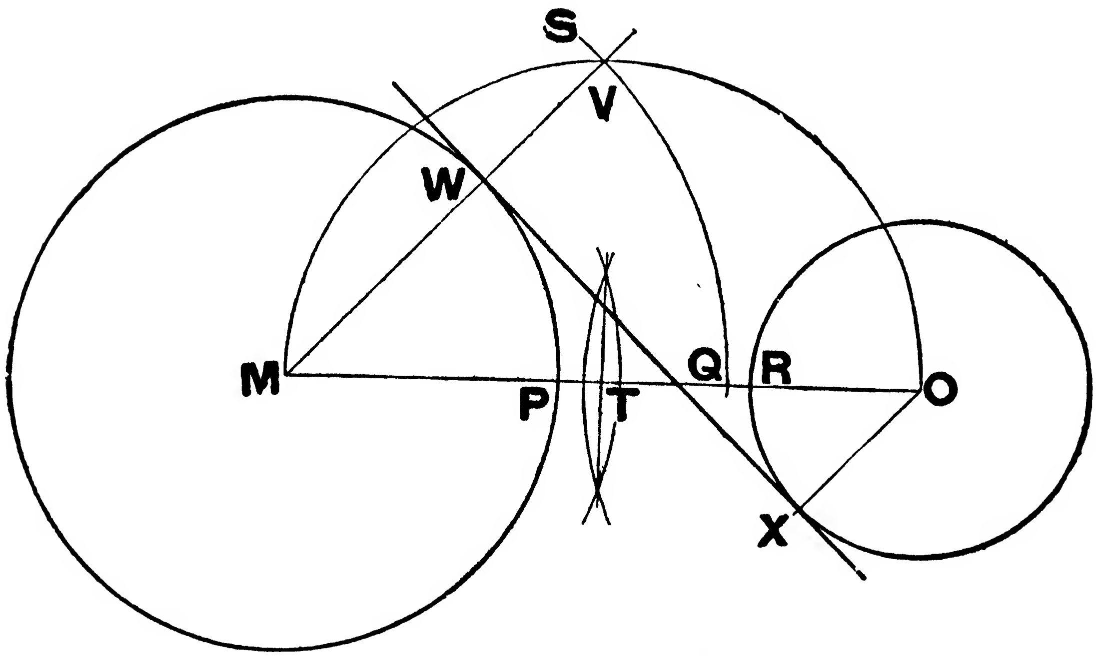


FIG. 154.—*Problem 17. To draw an interior tangent to two unequal circles.*

***Problem 17.**—To draw an interior tangent to two unequal circles M and O.*

In fig. 154, join centers M and O. Bisect MO, at T, and describe a semi-circle on MO. From P, on the larger circle, mark off PQ = OR, the radius of the smaller circle. With center M, and radius MQ, describe arc QS, cutting the semi-circle at V. Join MV, and mark point W. Draw OX. parallel with MV. Through the points of contact W and X, draw the interior tangent WX.

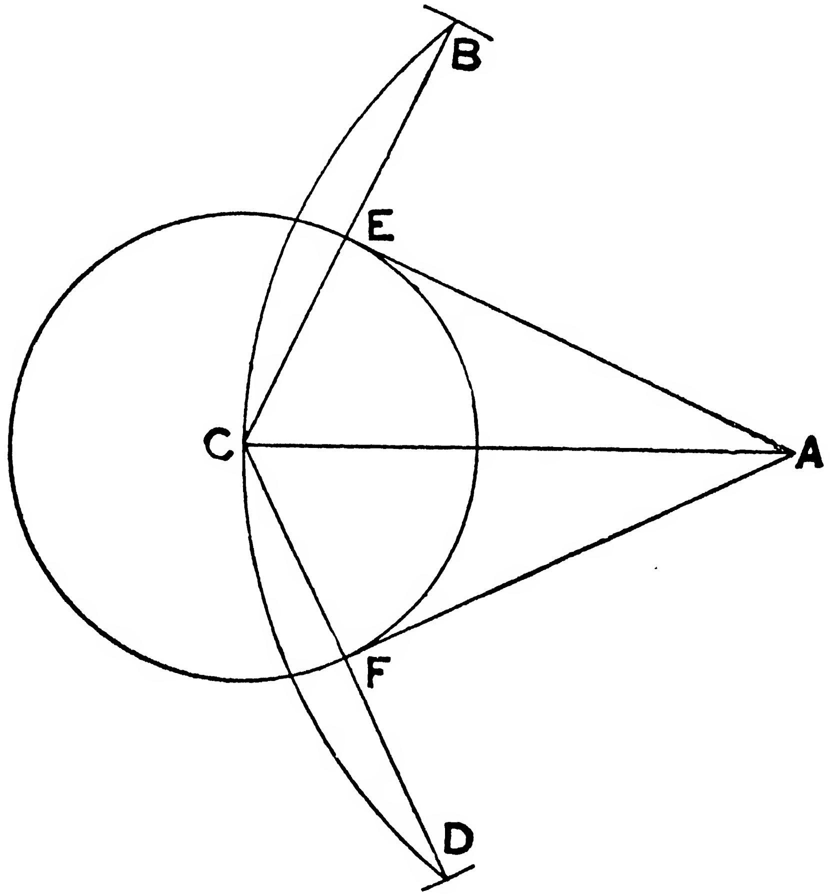


FIG. 155.—***Problem 18.*** *To draw tangents to a circle from points without.*

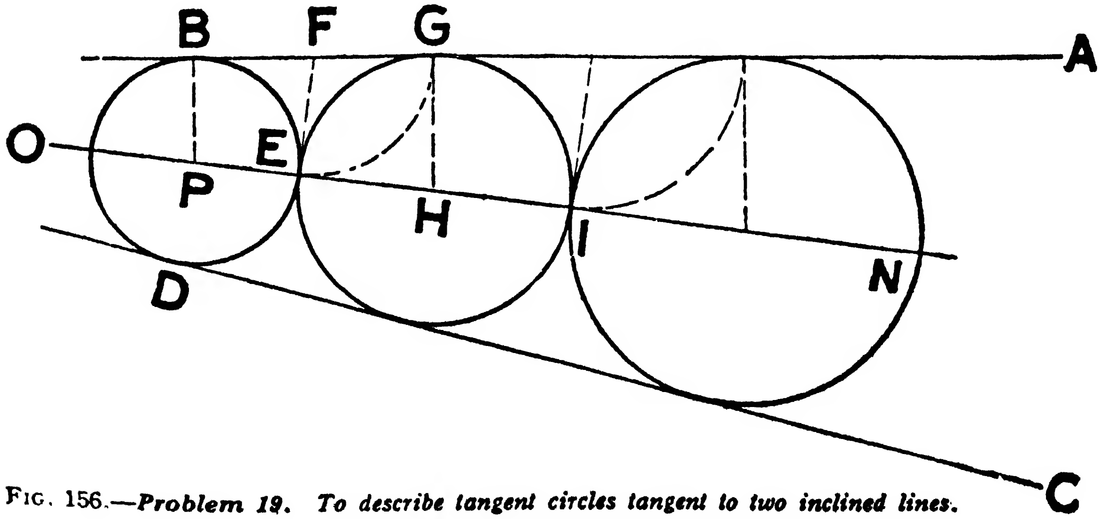


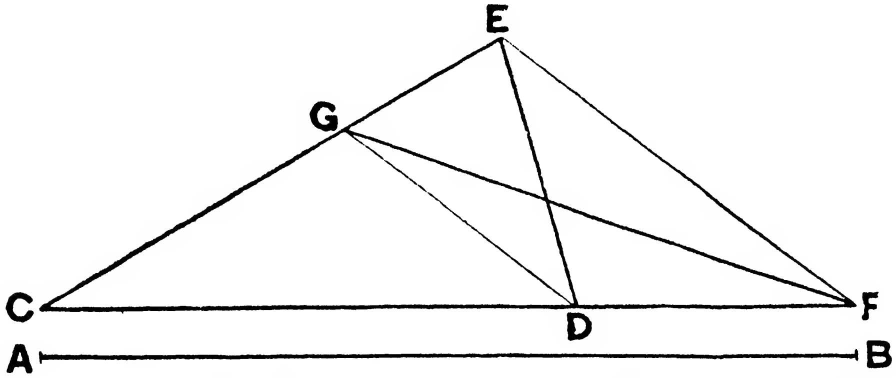
FIG. 156.—***Problem 19.*** *To describe tangent circles tangent to two inclined lines.*

Problem 18.—*To draw tangents to a circle from points without.*

In fig. 155, from A, and with the radius AC, describe an arc BCD, and from C, with a radius equal to the diameter of the circle, cut the arc at BD; join BC, CD, cutting the circle at EF, and draw the tangents, AF, AE.

Problem 19.—*Between two inclined lines to describe a series of circles tangent to these lines and tangent to each other.*

In fig. 156, bisect the inclination of the given lines AB, CD, by the line NO. From a point P, in this line, draw the perpendicular PB, to the line AB, and about P, describe the circle BD, touching the lines and cutting the center line at E. From E, draw EF, perpendicular to the center line, cutting



FIGS. 157 and 158.—*Problem 20. To construct a triangle having a given base and equivalent to any rectilineal figure*

AB, at F, and about F, describe an arc EG, cutting AB, at G Draw GH parallel with BP, giving H, the center of the next circle, to be described with the radius HE, and so on for the next circle IN.

Problem 20.—*To construct a triangle, having a given base A B, and equivalent to any rectilineal figure, say equal in area to the triangle CDE.*

In figs. 157 and 158, produce one side CD, to F, making CF, equal to the given base AB. Join FE. Draw DG, parallel to FE. Join FG. Then CFG, is the required triangle.

Problem 21.—*To construct a rectangle, when each of the diagonals is equal to A B, and each of one pair of opposite sides is equal to C D.*

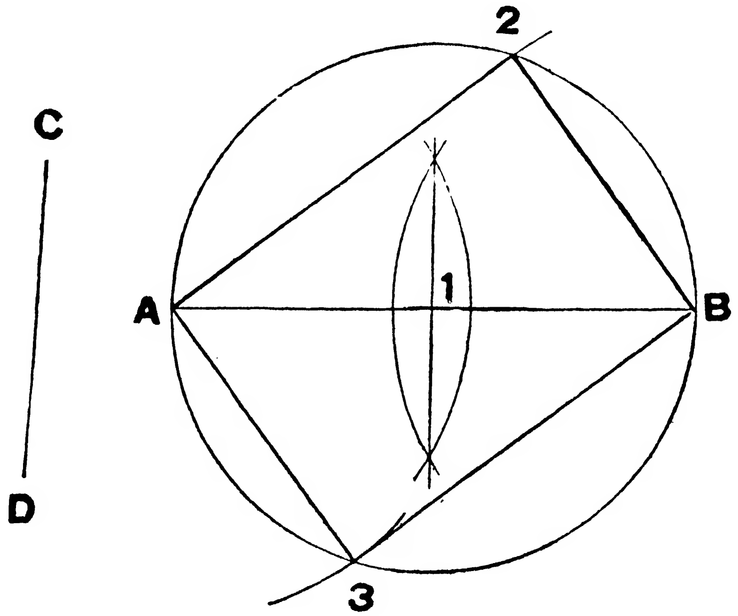
In figs. 159 and 160, bisect AB at 1, and with center 1, and radius 1A, describe a circle. With centers A and B, and radius CD, obtain points 2 and 3. Join A2, 2B, B3, 3A. Then A2B3 is the required rectangle. If

the longer side A2 be given, instead of the shorter side, then describe arcs at 2 and 3, with the longer side as radius.

Problem 22.—To construct a square, whose diagonal is given

In fig. 161 Bisect R S, by a perpendicular 2 3. Cut off 1 4, and 1 5, equal to 1R or 1S. Join R5, 5S, S4, 4R. Then R5S4 is the square required, having a given diagonal RS.

Problem 23.—To construct a square equal in area to any number of given squares.



FIGS 159 and 160.—*Problem 21. To construct a rectangle when each diagonal is equal to a given line and each of one pair of opposite sides is equal to another given line.*

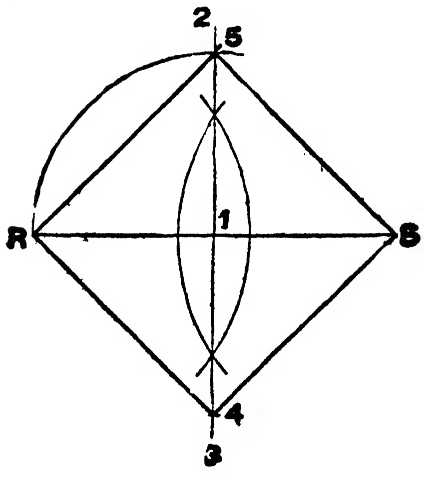
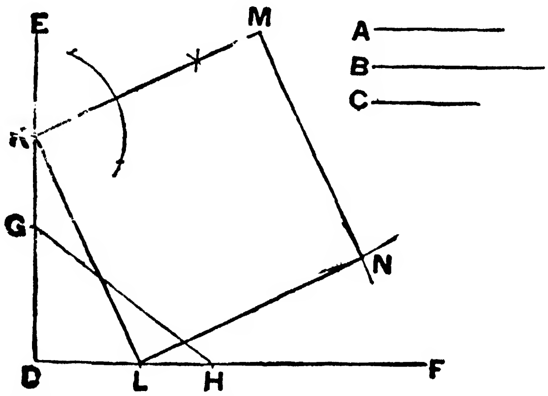


FIG. 161.—*Problem 22. To construct a square with given diagonal.*

In figs. 162 and 163:

Let A, B, C be the side of the three given squares. Make D G = A and D H = B. Join G H. Then the square upon G H equals the squares upon A and B. Make D K = G H and D L = C. Join K L. Then the square K L N M, equals the three squares upon A, B and C.



FIGS. 162 and 163.—*Problem 23. To construct a square equal in area to any number of given squares.*

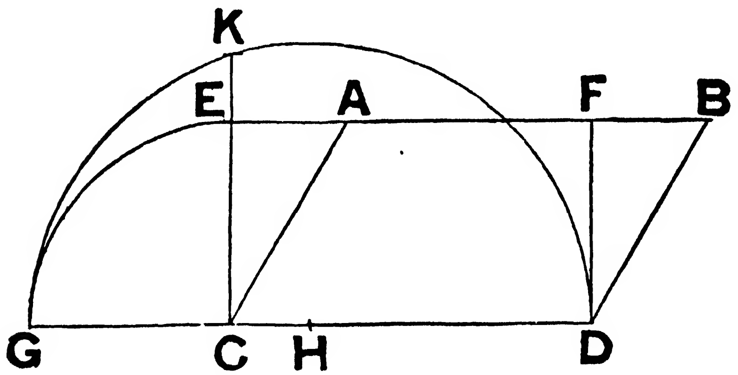


FIG. 164.—*Problem 24. To construct a square equal in area to any parallelogram.*

***Problem 24.**—To construct a square, equal in area to any parallelogram. Thus, construct a square equivalent to the rhomboid C D B A.*

In fig. 164, make the rectangle C D F E, equal to C D B A, by producing E F, and erecting perpendiculars C E, D F. Produce D C. Make C G, = C E. Bisect G D, at H. With center H, and radius H G, describe a semicircle. Produce C E, to K. Then C K, is the mean proportional if G C, C D, and a square constructed with C K as a side is equal in area to the rhomboid C D B A.

Problem 25.—Describe a catenary having given the span and versed sine.

In fig. 165, divide half span, as AB, into any required number of equal parts, as 1, 2, 3 and let fall BC and AO, each equal to versed sine of curve;

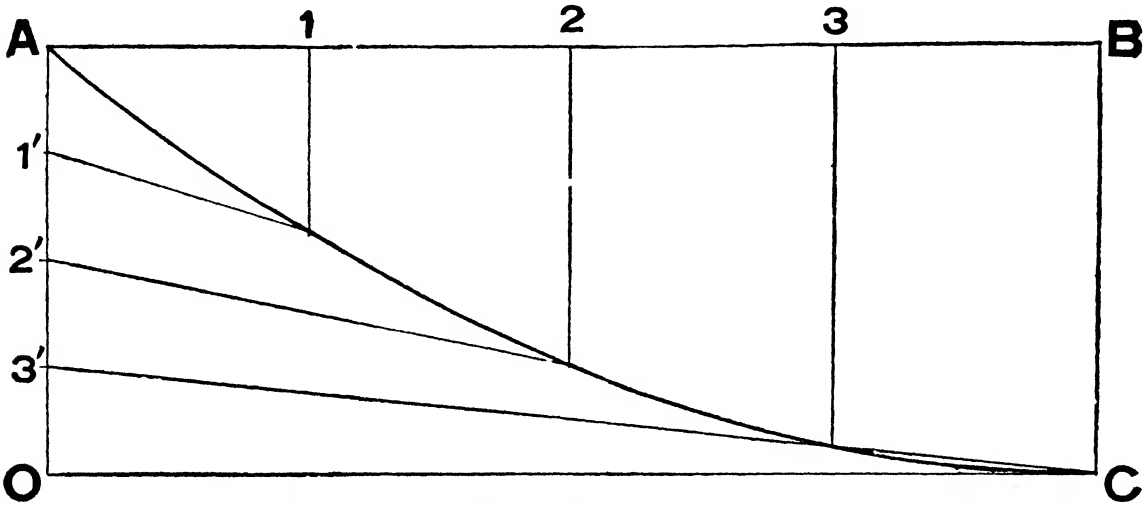


FIG. 165.—***Problem 25.** To describe a catenary having given the span and versed sine.*

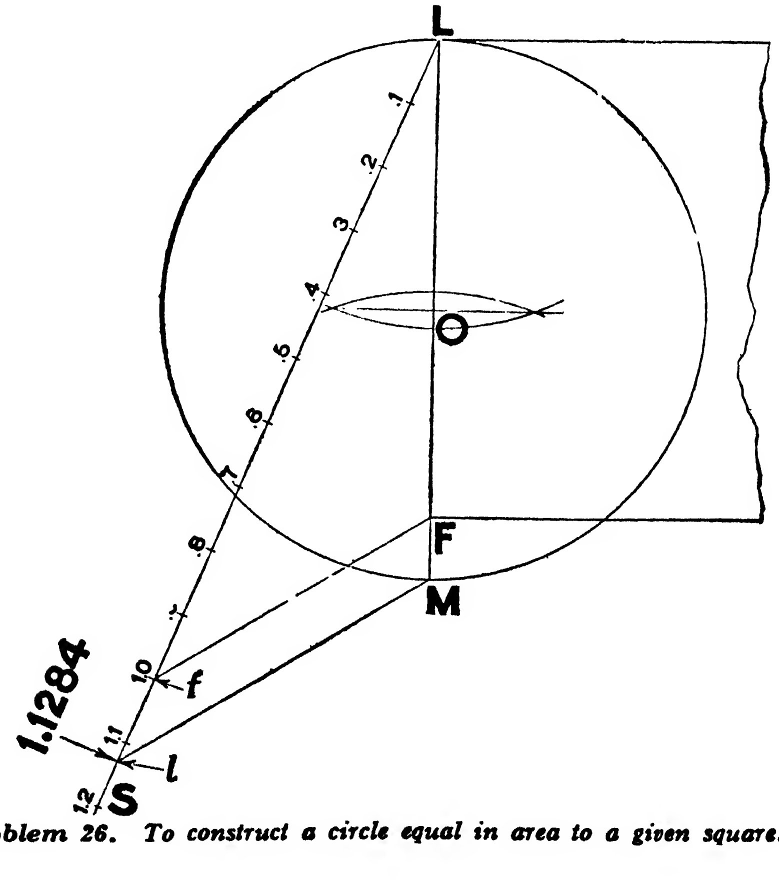


FIG. 166.—***Problem 26.** To construct a circle equal in area to a given square.*

divide AO into like number of parts, 1′, 2′, 3′, as AB. Connect C′1, C2′ and C3′ and points of intersection of perpendiculars let fall from AB will give points through which curve is to be drawn.

The catenary is the curve assumed by a perfectly flexible cord when its ends are fastened at two points, the weight of a unit length being constant.

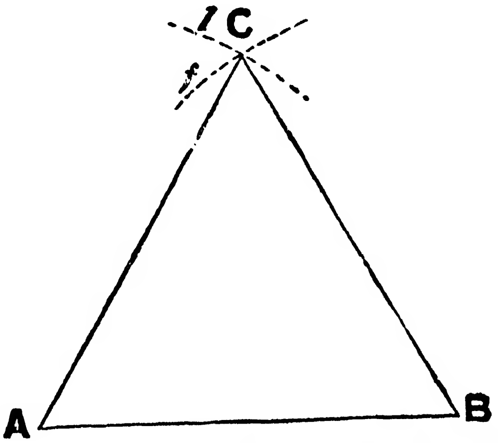


FIG. 167.—*Problem 27. To construct an equilateral triangle on a given base.*

Problem 26.—To construct a circle equal in area to a given square.

In fig. 166, let LF be side of the given square. Through L, draw proportional line L S, and with any convenient scale divide it into 12 equal parts. At the point *f*, or 10th division, draw line *f* F, and at a point *l*, between 11 and 12 draw *l* M parallel with *f* F. LM is the diameter of the required circle. Bisect this diameter at O and with radius O L describe the required circle.

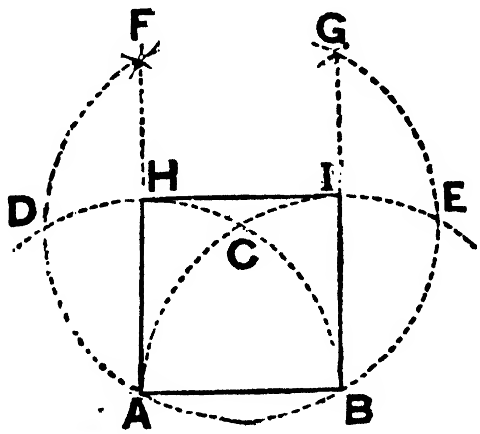


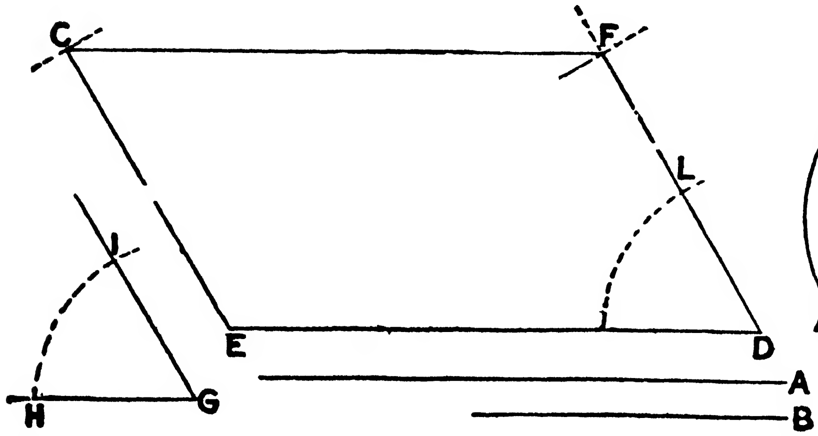
FIG. 168.—*Problems 28 and 29. To construct a square and a rectangle on a given base.*

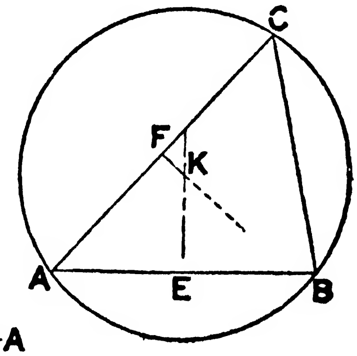
***Problem 27.**—To construct an equilateral triangle on a given base.*

In fig 167, with A, and B, as centers and radius equal to AB, describe arcs *l* and *j*. At their intersection C, draw lines CA, and CB, sides of the required triangle.

***Problem 28.**—To construct a square on a given base.*

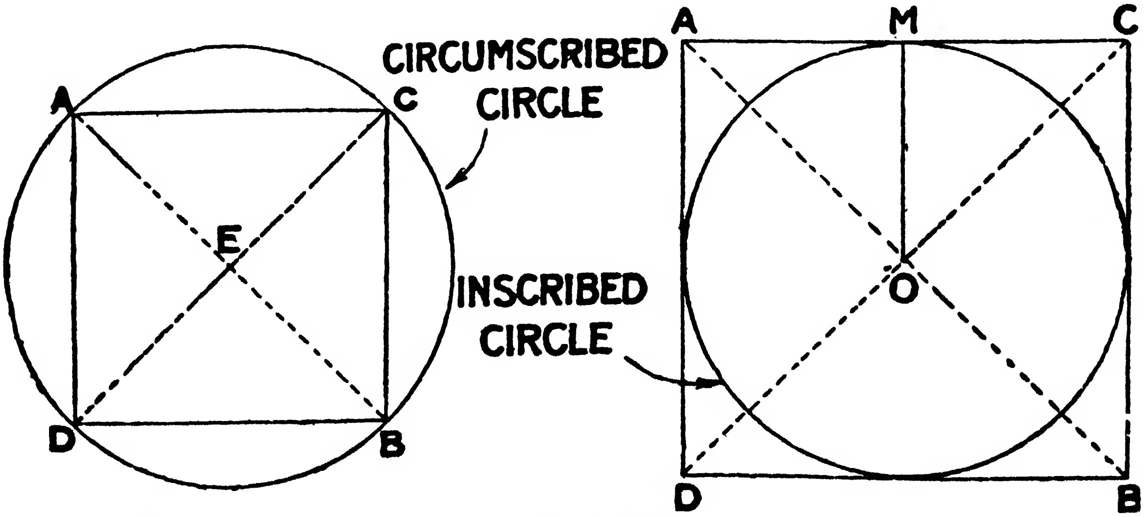
In fig. 168, with end points A and B, of base as centers and radius equal to AB, describe arcs cutting at C; with C as center, describe arcs





FIGS. 169 to 171.—***Problem 30.** To construct a parallelogram having given the sides and an angle.*

FIG. 172.—***Problem 31.** To describe a circle about a triangle.*



FIGS. 173 and 174.—***Problem 32.** To circumscribe about (fig. 173) and inscribe (fig. 174) circle in a square*

cutting the others at DE; and with D and E, cut these at FG. Draw AF, and BG, and join the intersections HI, then ABIH is the required square.

Problem 29.—To construct a rectangle on a given base.

In fig. 168, let AB, be given base. Erect perpendiculars at A and B, equal to altitude of the rectangle, and join their ends H and I, by line HI, ABIH, is the rectangle required.

Problem 30.—To construct a parallelogram having given the sides and an angle.

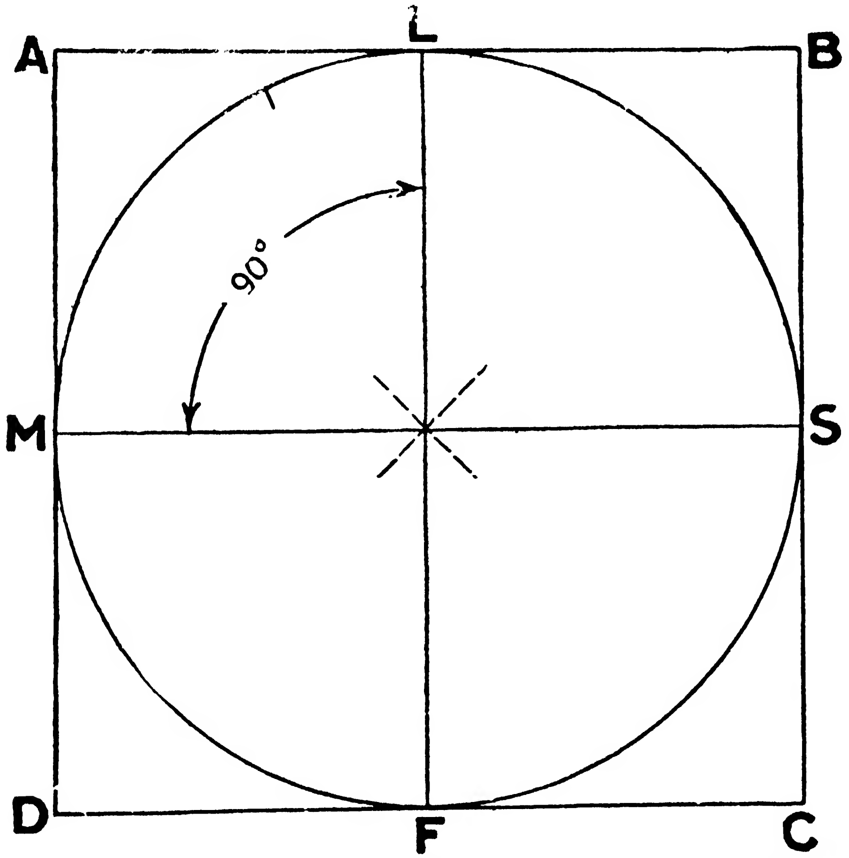


FIG. 175.—*Problem 33. To circumscribe a square about a circle. Second method*

In figs. 169 to 171, draw side DE, equal to the given length A, and set off the other side DF, equal to the other length B, forming the given angle IGH. From E, with DF, as radius, describe an arc, and from F, with the radius DE, cut the arc at C. Draw FC, EC. Or, the remaining sides may be drawn as parallels to DE, DF

Problem 31.—To describe a circle about a triangle.

In fig. 172, bisect two sides AB, AC, of the triangle at E and F, and

from these points draw perpendiculars intersecting at K. From the center K, with the radius KA, describe the circle ABC.

Problem 32.—*To circumscribe about and inscribe a circle in a square.*

In fig. 173, draw the diagonals AB and CD, intersecting at E. With

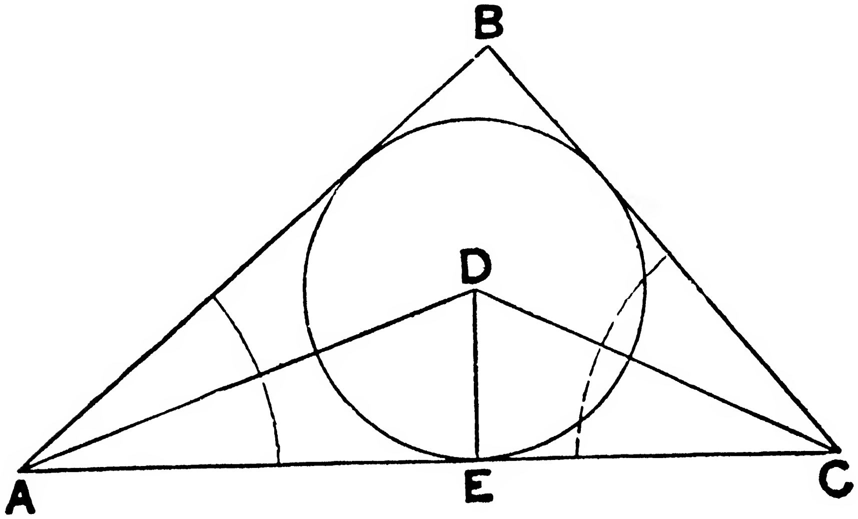


FIG. 176.—***Problem 34.*** *To inscribe a circle in a triangle.*

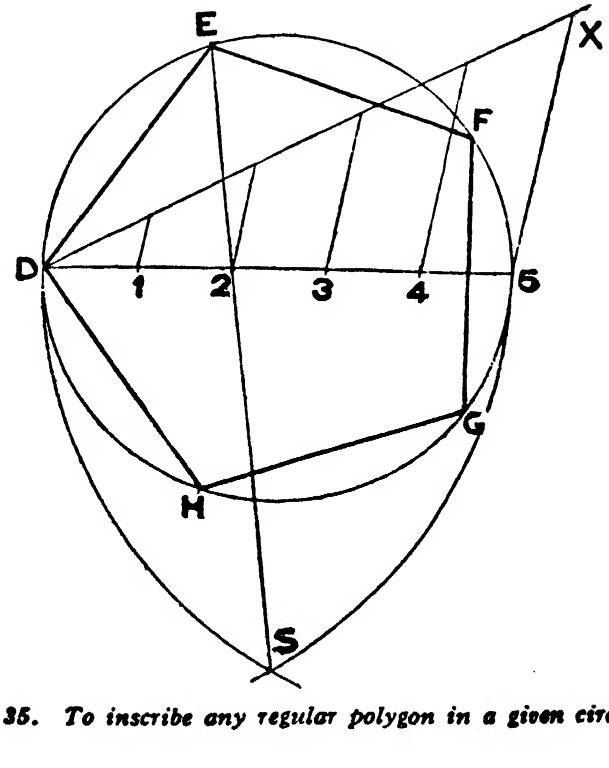


FIG. 177.—***Problem 35.*** *To inscribe any regular polygon in a given circle.*

radius EA, circumscribe the circle. To inscribe a circle let fall from the center (as just found) a perpendicular to one side of the square as OM, in fig. 174. With radius OM, inscribe the circle.

Problem 33.—To circumscribe a square about a circle.

In fig. 175, draw diameters MS and LF, at right angles to each other. At the points M, L, S, F, where these diameters cut the circle, draw tangents that is, lines perpendicular to the diameter, thus obtaining the sides of the circumscribed square ABCD.

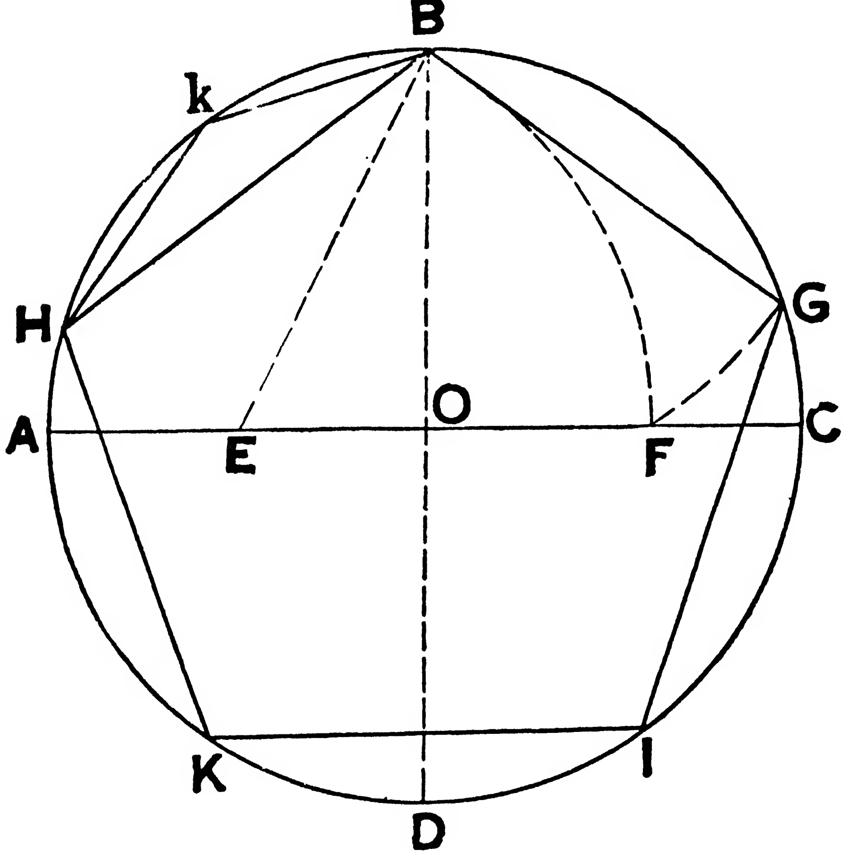


FIG. 178.—*Problem 36. To inscribe a pentagon in a circle.*

Problem 34.—To inscribe a circle in a triangle.

In fig. 176, bisect two of the angles A and C, of the triangle by lines cutting at D; from D, draw a perpendicular DE, to any side, and with DE, as radius, describe a circle.

Problem 35.—To inscribe any regular polygon in a given circle.

In fig. 177, draw a diameter D 5. Divide D 5, into as many equal parts

as the polygon is to have sides, in this case, five equal parts. With points D and 5, as centers, and the diameter D 5, as radius, describe arcs intersecting at 6. From 6, draw a line through Point 2 to E. Join D E, which is one side of the required polygon. Make E F, F G, G H, each equal D E. Join E F, F G, G H, H D. Then D E F G H, is the required polygon.

This method is only approximately correct. It is however, sufficiently accurate for all practical work. On the same principle, an arc can (approximately) be divided into any number of equal parts, or a circle into equal sectors. By this method, a regular polygon having any number of sides

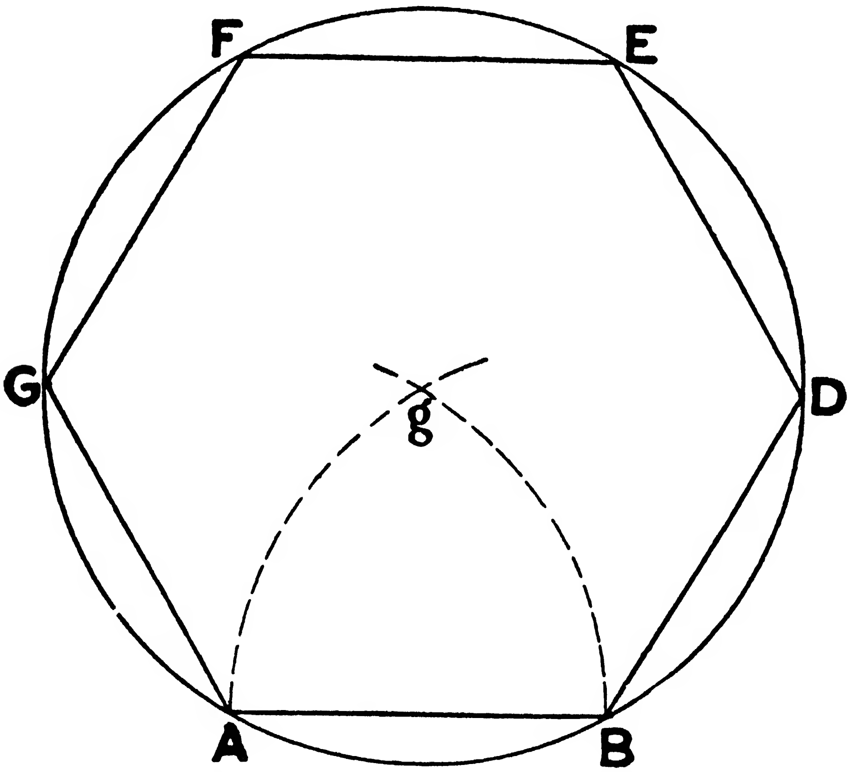


FIG. 179.—*Problem 37. To construct a hexagon upon a given straight line.*

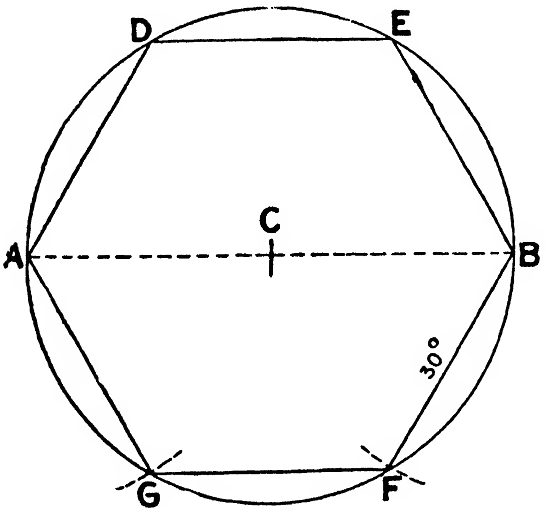
can be inscribed, (approximately) within a given circle. If a nonagon is to be inscribed, divide the diameter into nine equal parts, and then proceed as above. To get the first side of the polygon, always draw a line from point 6; through the 2nd division on the diameter, no matter how many sides the polygon is to have. In a polygon, that has an even number of sides, a line drawn from one angle to the opposite angle (a diagonal) passes through the center. When there is an odd number of sides, a line from an angle through the center, bisects the opposite side. Note these facts as tests for accuracy in the work.

***Problem 36.**—To inscribe a pentagon in a circle.*

In fig. 178, draw two diameters, AC, BD, at right angles intersecting at O; bisect AO, at E, and from E, with radius EB, cut AC, at F, and from B, with radius BF, cut the circumference at G,H, and with the same radius step round the circle to I and K; join the points so found to form the pentagon.

***Problem 37.**—To construct a hexagon upon a given straight line.*

In fig. 179, from A and B, the ends of the given line describe arcs intersecting at g, from g, with the radius gA, describe a circle. With the same radius set off the arcs AG, GF and BD, DE. Join the points so found to form the hexagon.



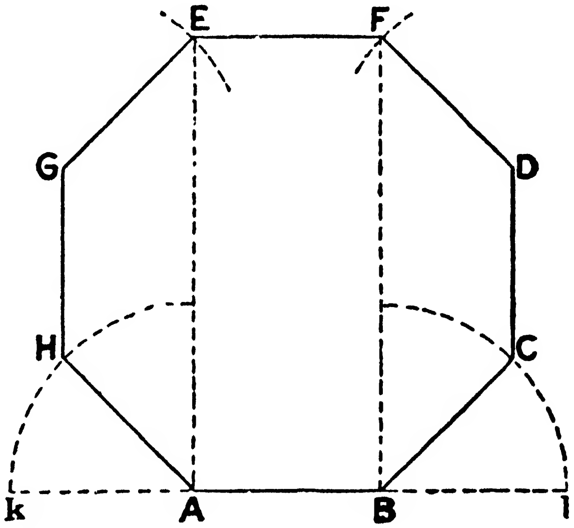


FIG. 180.—***Problem 38.** To inscribe a hexagon in a circle.*

FIG. 181.—***Problem 39.** To construct an octagon on a given straight line.*

***Problem 38.**—To inscribe a hexagon in a circle.*

In fig. 180, draw a diameter ACB; from A and B, as centers with the radius of the circle AC, cut the circumference at D,.E, F, G, and draw AD, DE, etc., to form the hexagon.

The points DE, etc., may be found by stepping the radius (with the dividers) six times round the circle.

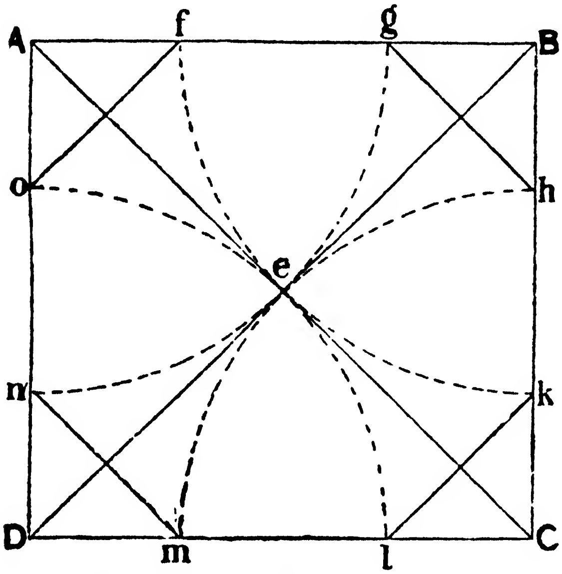
***Problem 39.**–To construct an octagon on a given straight line.*

In fig. 181, produce the given line AB, both ways, and draw perpendiculars AE, BF; bisect the external angles A and B, by the lines AH, BC, which make equal to AB.Draw CD and HG parallel with AE and equal to

AB; from centers G, D, with the radius AB, cut the perpendiculars at EF, and draw EF, to complete the octagon.

Problem 40.—*To inscribe an octagon in a square.*

In fig. 182 draw the diagonals of the square intersecting at *e*; from the



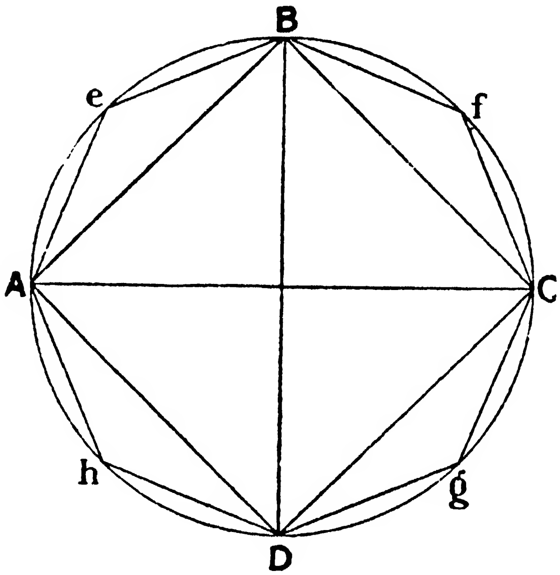
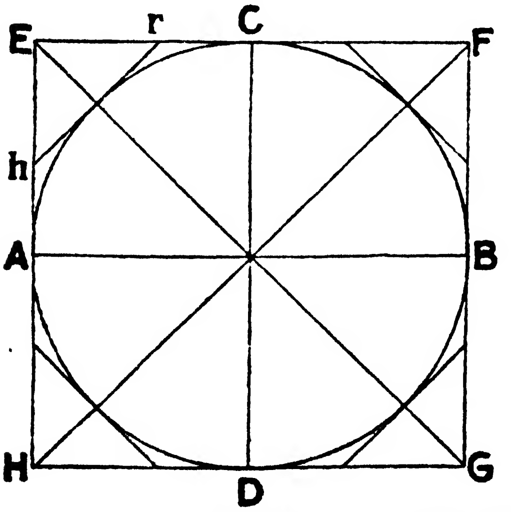


FIG. 182.—***Problem 40.*** *To inscribe an octagon in a square.*
FIG. 183.—***Problem 41.*** *To inscribe an octagon in a circle.*



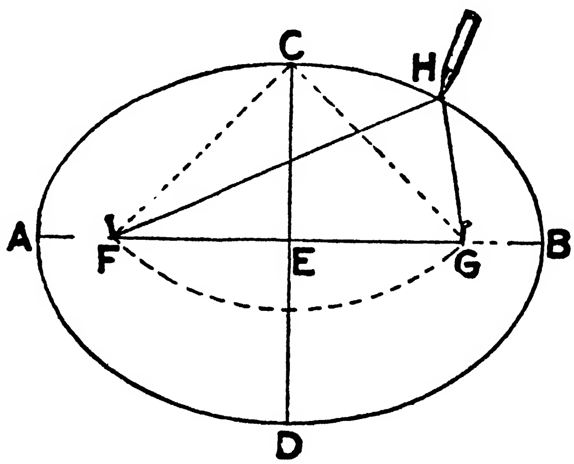


FIG. 184.—***Problem 42.*** *To circumscribe an octagon about a circle.*
FIG. 185.—***Problem 43.*** *To describe an ellipse when the two axes are given.*

corners A,B,C,D, with A*e*, as radius, describe arcs cutting the sides at *g*, *h*, etc.; and join the points so found to complete the octagon.

Problem 41.—*To inscribe an octagon in a circle*

In fig. 183, draw two diameters AC, BD, at right angles; bisect the arcs AB, BC, etc., at *e*, *f*, etc., and join the points of division to form the octagon.

Problem 42.—*To circumscribe an octagon about a circle.*

In fig. 184, circumscribe a square EFGH, about the given circle Draw

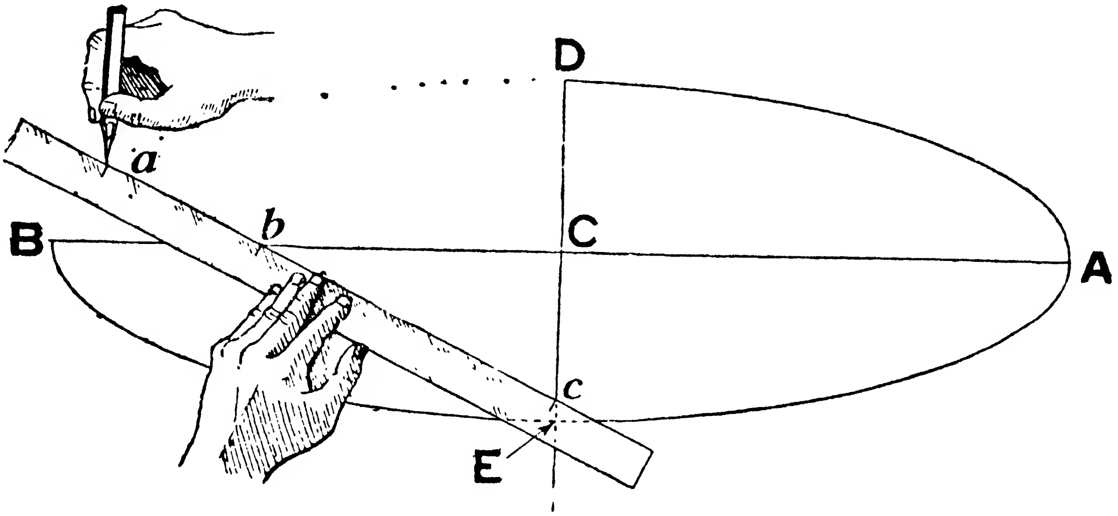


FIG. 186.—***Problem 43.*** *Second method.*

diagonals HF and EG, and tangents *h r*, etc., through points where the diagonals cut the circle to form with the intercepts, the octagon.

Problem 43.—*To describe an ellipse when the two axes are given*

In fig. 185, draw the major and minor axes AB and CD, at right angles, intersecting at E. On the center C, with AE, as radius, cut the axis AB, at F and G, the *foci;* insert pins through the axis at F and G, and loop a thread or cord upon them equal in length to the axis AB, so that when stretched it reaches the extremity C, of the *minor axis*, as shown in dotted lines. Place a pencil inside the cord, as at H, and guiding the pencil in this way, keeping the cord equally in tension, carry the pencil round the pins FG, and so describe the ellipse.

Second Method.— In fig. 186 along the edge of a piece of paper, mark off a distance *ac*, equal to AC, half the major axis, and from the same point, a distance *ab*, equal to CD, half the minor axis. Place the slip so as to bring the point *b*, on the line AB, or major axis, and the point *c*, on the line DE, or minor axis. Set off the position of the point *a*. Shifting the slip, so that the point *b*, travels on the major axis, and the point *c*, on the minor axis, any number of points in the curve may be found, through which the curve may be traced.

***Problem 44.**—To construct a spiral or volute, by means of tangential arcs of circles.*

Construct a square 1 2 3 4, and produce the sides, fig. 44. With center 2, and radius 2 1, describe arc 1 A; center 3, and radius 3 A, describe arc A B; center 4, and radius 4 B, describe arc B C; center 1, and radius 1 C, describe C D; center 2, and radius 2 D, describe D E. In the same way describe any number of arcs, E F, F G, G H. The curve obtained is a spiral or volute. 1 2 3 4, is the eye of the spiral. The eye can be formed by any regular or irregular rectilineal figure, not having a re-entrant angle. In every case, proceed as above.

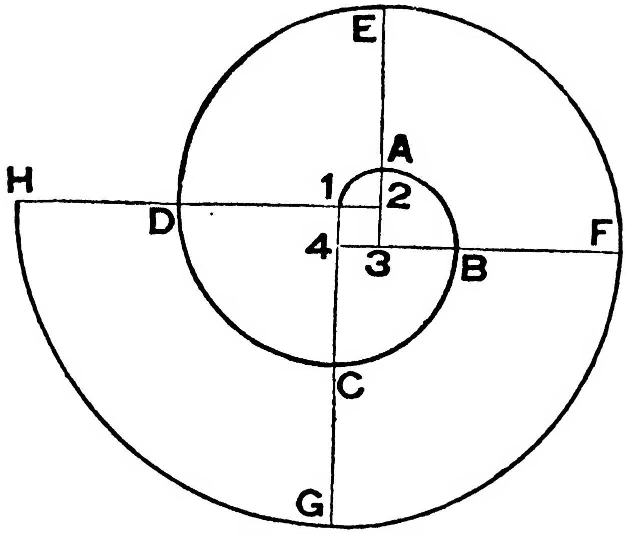


FIG. 187.—***Problem 44.** To construct a spiral or volute, by means of tangential arcs of circles.*

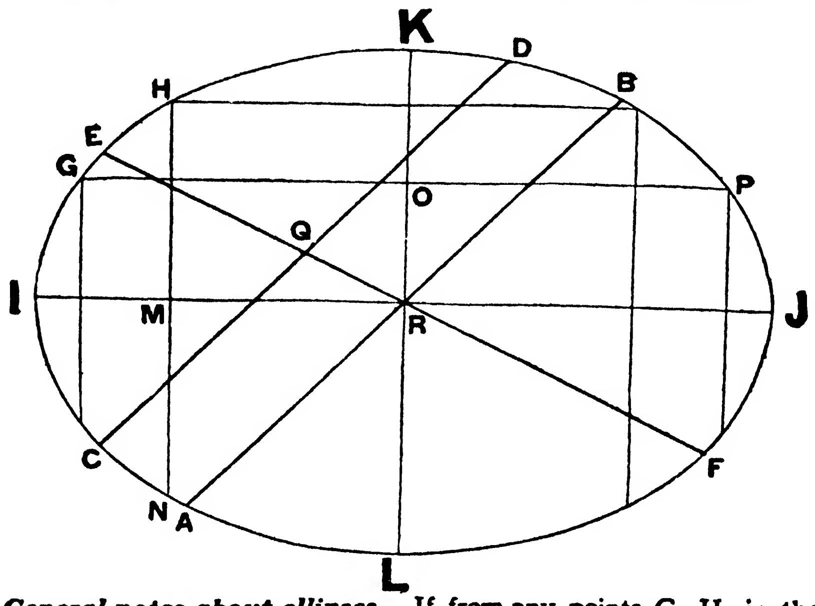


FIG. 188.—***General notes about ellipses.*** If from any points G, H, in the curve of an ellipse, lines parallel to the major axis I J, be drawn, or to the minor axis K L, be drawn, and the distance M N, be made equal to M H, or O P, be made equal to O G, other points, N, P, in the elliptic curve are obtained. A line Q C, or Q D, drawn from any point Q, in a diameter E F, and parallel to a conjugate diameter A B, is called an ordinate. M H, O P, are also ordinates. The whole line C D, H N, or G P, is a double ordinate. Draw any cord C D, parallel to A B. Bisect A B, C D, at Q R. Then E F, drawn through Q R, is a *conjugate diameter* to A B. The minor axis is called "the conjugate axis," because of its relationship to the major axis. The major and minor axes are a *pair* of conjugate diameters.

***Problem 45.**—To find the foci of an ellipse and then to draw the elliptic curve by means of intersecting arcs, the major axis P Q and minor axis T V being given.*

In fig. 189, with T, one end of the minor axis, as center and X Q, half the major axis as radius, describe arcY, cutting the major axis at F′, F″. These points are the required foci. Between F′ and X, mark any number of points 1, 2, 3, 4. With centers F′, F″, and radius PI, describe arcs *a, a, a, a*. With the same centers and radius Q 1, cut arcs *a, a, a, a*, at *b, b, b, b*. With each focus as center and radius P2, describe arcs, *c, c, c, c*. With the

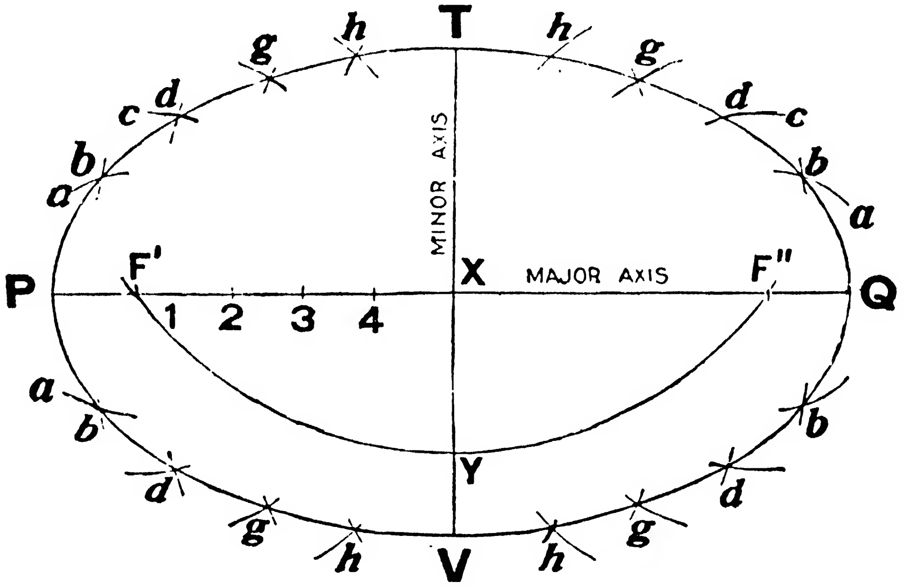


FIG. 189.—***Problem 45.** To construct an ellipse having given minor and major axes.*
FIG. 189 —***Problem 46.** The major axis and foci of an ellipse being given to find the minor axis.*

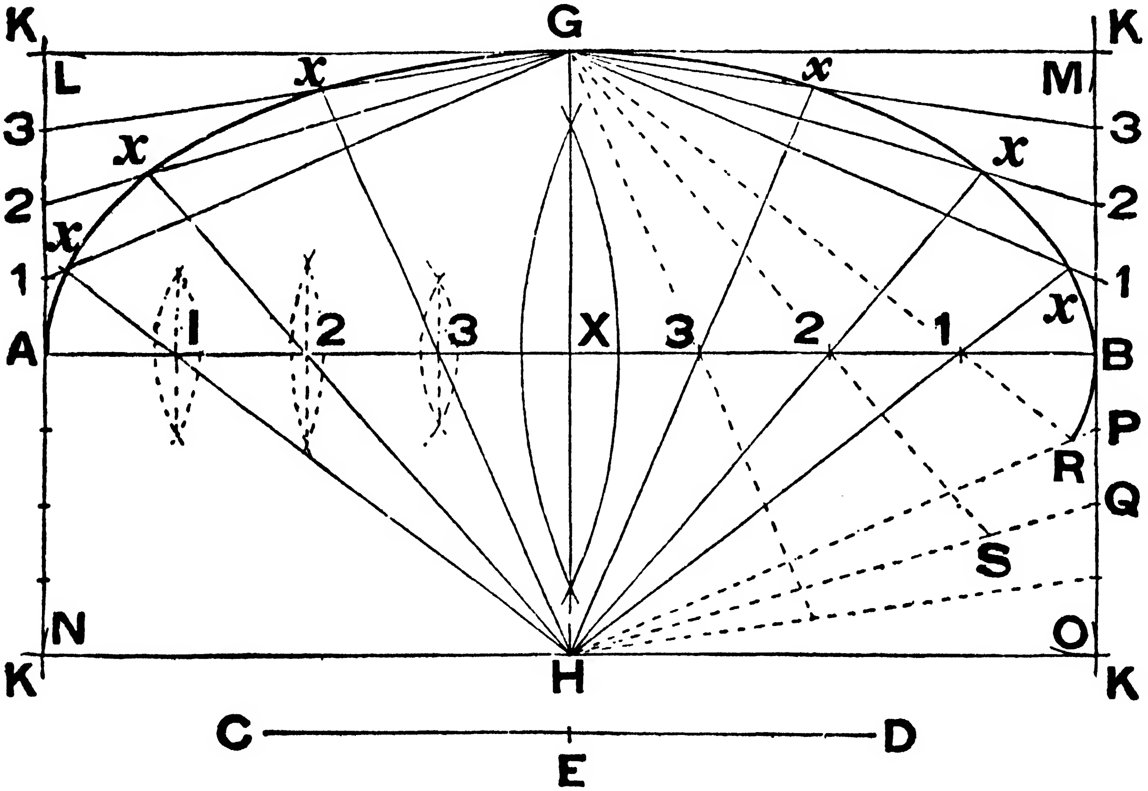
same centers and radius Q 2, cut these arcs at *d, d, d, d*. In the same way use points 3 and 4, to get *g, g, h, h*. Through points *b, d, g, h,* draw the curve of the ellipse. The points 1, 2, 3, 4 may be at any distance apart, but it is more convenient to let the divisions decrease in length toward F′. Do not make the arcs too long, as this causes confusion.

***Problem 46.**—The major axis and foci of an ellipse being given to find the minor axis.*

In fig. 189, bisect P Q, at X. With X P, or X Q, as radius and the foci as centers, strike arcs cutting at T and V. Join T V. Then T V, is the minor axis.

***Problem 47.**—Draw the curve of an ellipse by means of intersecting lines. The lengths of the major and minor axes AB, and CD, being given.*

In figs. 190 and 191 bisect CD at E. Bisect AB, at X, by a perpendicular. Make X G, X H, each equal to E C, or E D. With centers G, H, and radius X A, describe arcs at K, K,K,K. With centers A, B, and radius X G, cut these arcs at L, M, N, O. Join L M, M O, O N, N L. Divide A L, A N, B M, B O, A X, B X, each into the same number of equal parts, say four. Draw lines from G, to 1, 2, 3, on A L, B M. From H, through 1 (on A X), draw a line to meet 1 G, at *x*. Through 2, draw a line from H, to meet 2 G, at



FIGS. 190 and 191.—***Problem 47.** Draw the curve of an ellipse by means of intersecting lines*

x. Through 3, draw a line to meet 3 G, at *x*. In the same way get points *x,x,x*, on the other side. Also get similar points for the lower half of the ellipse, as shown by dotted lines at R and S. Through *x,x,x*, R, S, draw the curve of the ellipse. The divisions on A L, A X, may be unequal, provided those on A X, be proportional to those on A L. A French curve may be used for drawing the elliptic curve, through the points *x,x,x*. By this method, an ellipse may be inscribed in any rectangle. By joining A G, G B, B H, H A, a rhombus is obtained. Therefore an ellipse can be circumscribed about a rhombus, or a rhombus can be inscribed in an ellipse.

***Problem 48.**—The curve or portion of the curve of an ellipse being given, to find the center and the major and minor axes.*

In fig. 192, draw two parallel chords A B, C D. Bisect them at E and F, Through E, F, draw G H, which is a diameter. Bisect it at K, which is the center of the ellipse. With center K, and any convenient radius, describe the arc L M N. With centers L and M, and any radius, describe arcs cutting at O From O, through K, draw P Q, which is the major axis.With centers M and N; and any radius, describe arcs cutting at R. From R, through K, draw T S, which is the minor axis. Instead of describing arcs at O and R, L M, M N, may be joined and the axes through K, parallel with L M, M N, drawn.

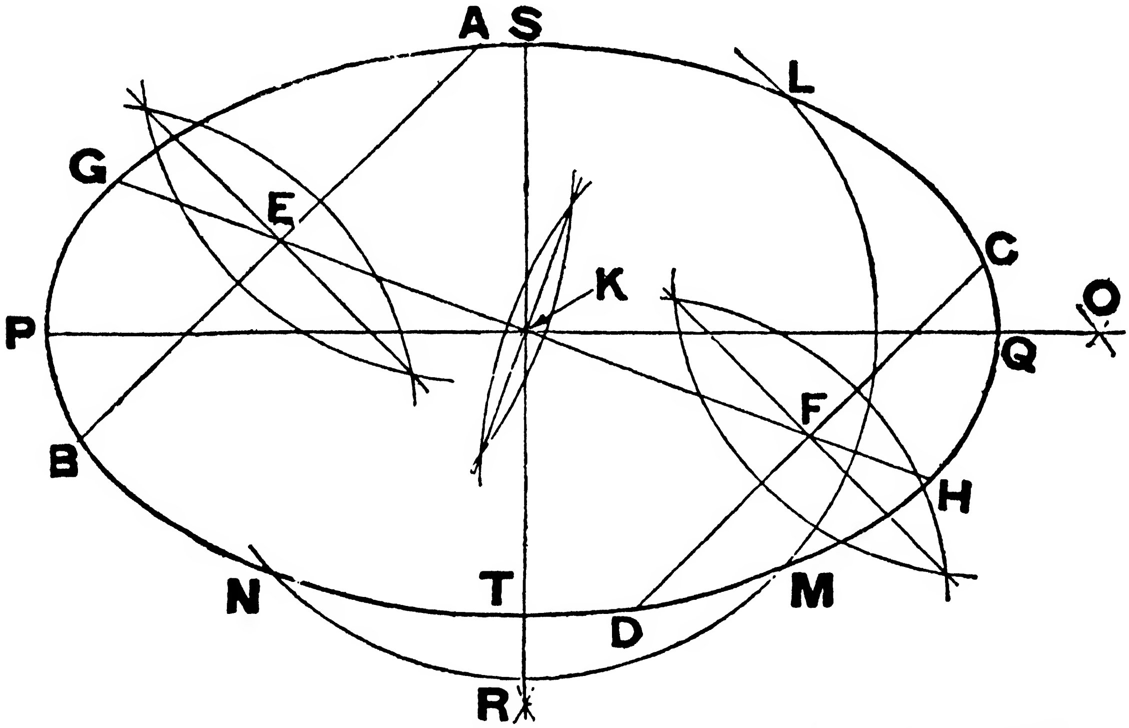


FIG. 192.—*Problem 48. The curve or portion of the curve of an ellipse being given, to find the center and the major and minor axes.*

For convenience, the given ellipse may be drawn with a piece of thread as shown in fig 185. If a small portion of the curve be given, the chords A B, C D, must be drawn closer together, If only one end of G H, meet the curve, draw another pair of parallel chords, and get another diameter, then the intersection of the two diameters gives the center. The portion of the curve given should contain at least one end of each axis.

NOTE.—*To draw an ellipse* when the foci and one point in the curve are given. Draw a line of indefinite length through the foci. Draw a line from each focus to the given point. The sum of these two lines gives the length of the major axis. With half the major axis as radius, and the foci as centers, describe arcs intersecting at points, which give the ends of the minor axis. Obtain the curve of the ellipse.

***Problem 49.**—At any point A, in the curve of an ellipse, to draw a normal; and through any point B in the curve to draw a tangent.*

In fig. 193, draw the ellipse with a piece of thread. From each focus, draw a line through A, to D, and C. Bisect angle D A C, by A E. The line A E, is the required normal (or perpendicular). From the foci draw lines to B. Produce one of the lines, say to G. Bisect the angle G B F″, by H K. Then the line H K is the required tangent. The normal may also be obtained by bisecting the angle F′ A F″. To draw a normal at either

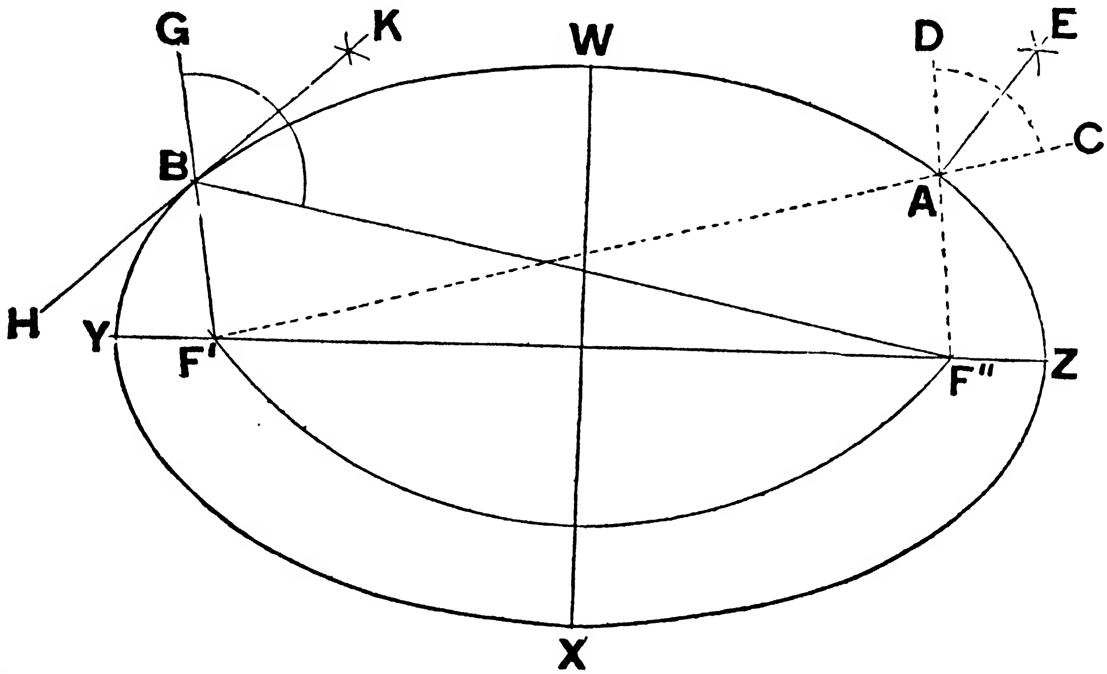


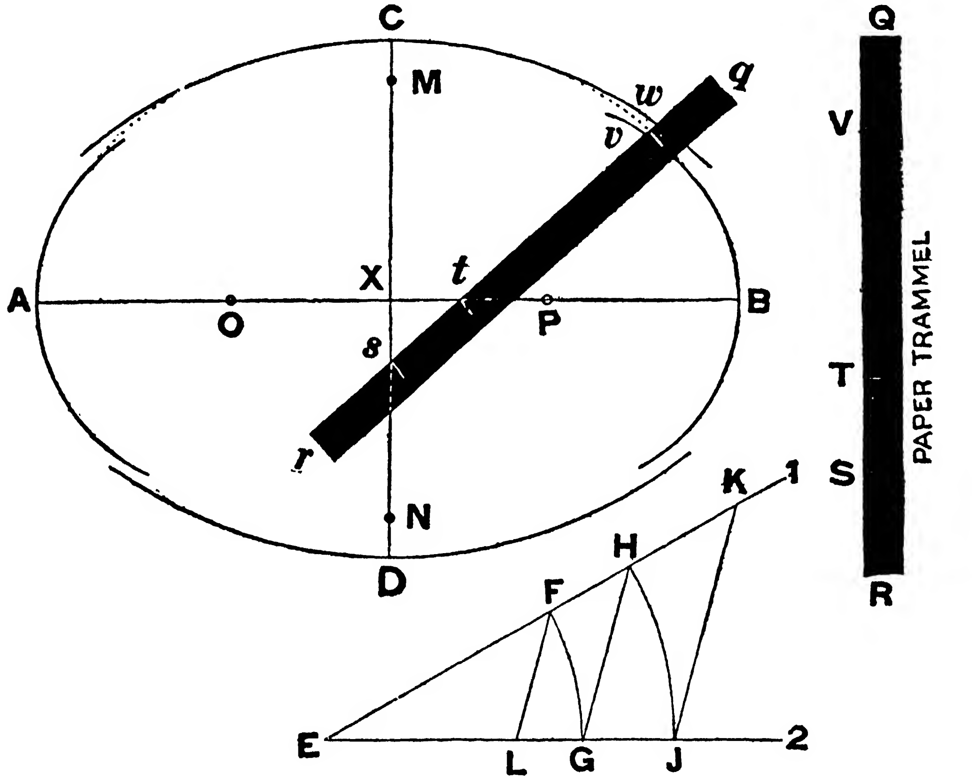
FIG. 193.—***Problem 49.** At any point in the curve of an ellipse to draw a normal, and through any point in the curve to draw a tangent.*

extremity of the major or minor axis, simply produce the axis. A tangent at either extremity of the major or minor axes must be drawn at right angles to the axis.

NOTE.—***To draw tangential lines to an ellipse from a given point outside the curve.*** Call given point 1, and place it in any position with regard to ellipse. With 1, as center and the distance to the nearer focus, as radius, describe about half of a circle cutting the ellipse in two places. With the further focus as center and the major axis as radius, cut the arc in points 2 and 3. From points 2 and 3, draw lines to the further focus. These lines cut the ellipse in two points. Call these points 4 and 5; they are the required points of contact. Draw two lines from the given point 1, through points 4 and 5; and these lines are the required tan gents.

***Problem 50.**—To get the curve of an ellipse approximately with arcs of circles, and by the use of a paper trammel.*

In figs. 194 to 196, lines A B, C D, are major and minor axes. Drew E 1. E 2, at any angle. Make E G = X C, and E H = X A. Join G H. With center E, and radii E G, E H, strike the arcs G F, H J. Draw F L, J K, parallel with G H. Make D M, C N, equal to E K, and A O, B P, equal to E L. With centers N and M, and radius N C, describe arcs passing through C and D With centers O, P, and radius O A, describe arcs at A and B. These four arcs give approximately parts of the ellipse. On one edge of a straight



FIGS. 194 to 196.—***Problem 50.** To get the curve of an ellipse approximately with arcs of circles and by the use of a paper trammel. **This method applies** only when the minor axis is more than about 3/5 of the major axis. In making a narrow ellipse M and N will fall outside the ellipse.*

slip of paper Q R, set off V S, equal to A X, and V T, equal to C X. Then use Q R, as a trammel. Adjust the trammel Q R, in such a manner, that

NOTE.—***To describe an ellipse,*** having one diameter given, similar to any given ellipse. In two similar ellipses, any two conjugate diameters of one ellipse have the same proportion to each other as the corresponding conjugate diameters of the other ellipse have to each other. Therefore find a fourth proportional to the given diameter, and the two diameters of the given ellipse. This fourth proportional gives the length of the other diameter of the required ellipse. Place the two diameters bisecting each other, and at the required angle and describe the ellipse.

point *t*, rests somewhere on the major axis; and point *s*, on the minor axis. Wherever point *v*, comes, will be a point situated in the curve of the ellipse. Mark several points as at *w*, and through these points draw curves connecting the arcs. E L, is a third proportional less, and E K, is a third proportional greater, to the lines E G, E H. A French curve may be used to connect the arcs through the points at *w*. The entire curve can be drawn by means of points obtained with a trammel. When an ellipse has a short minor axis, the points M and N, fall outside the ellipse, on the minor axis produced. This method is exceedingly useful when representing circles in perspective, and also in mechanical drawing when describing ellipses.

Mensuration

Mensuration is *the process of measuring.*

It is that branch of mathematics that has to do with finding the length of lines, the area of surfaces, and the volume of solids. Accordingly the problems which follow will be divided into three groups, as:

1. Measurement of lines.

   a. One dimension, *length*

2. Measurement of surfaces (*areas*).

   a. Two dimensions, *length* and *breadth*

3. Measurement of solids (*volumes*).

   a. Three dimensions. *length, breadth,* and *thickness*

1. Measurement of Lines

(length)

Problem 1.—To find the length of any side of a right triangle, the other two sides being given.

Rule.—*Length of hypotenuse equals square root of the sum of*

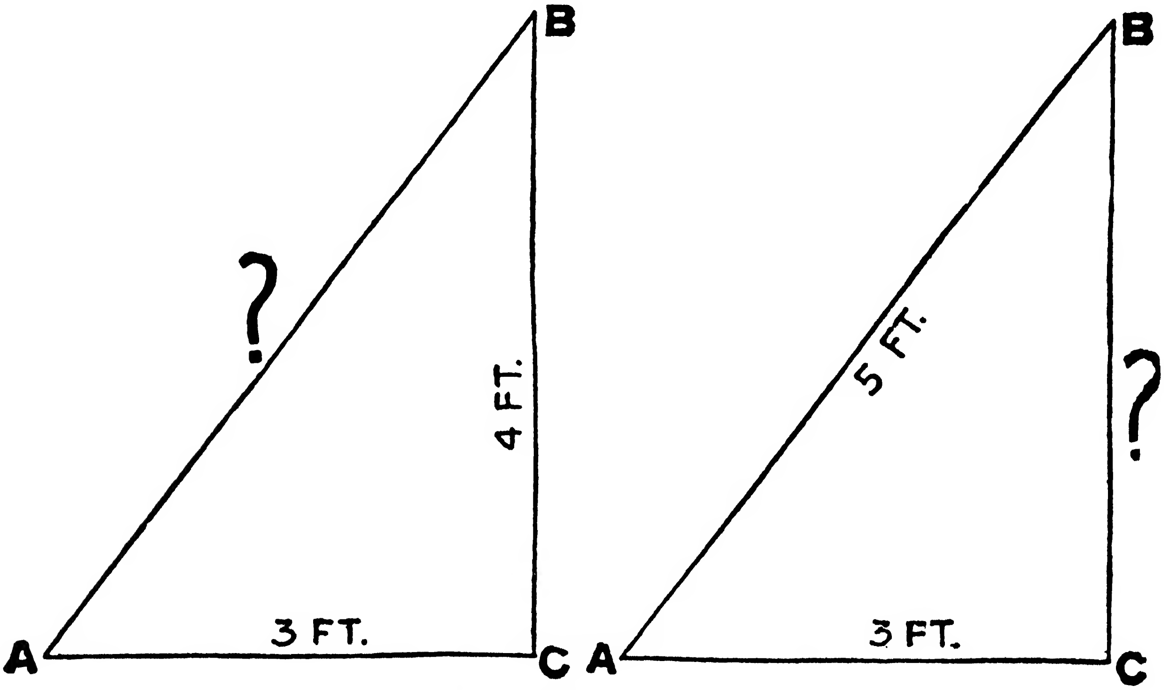
the squares of the two legs; length of either leg equals square root of the difference of the square of the hypotenuse and the square of the other leg.

Example.—The two legs of a right triangle measure 3 and 4 ft.; find length of hypotenuse. If the length of hypotenuse and one leg be 5 and 3 ft. respectively, what is the length of the other leg?

In fig 197

$$AB = \sqrt{3^2 + 4^2} = \sqrt{25} = 5$$

In fig. 198 $BC = \sqrt{5^2 - 3^2} = \sqrt{25 - 9} = \sqrt{16} = 4.$



FIGS. 197 and 198:—*Problem 1. To find the length of any side of a right triangle.*

Problem 2.—To find length of circumference of a circle.

Rule.—*Multiply the diameter by* 3.1416.

Example.—What length of moulding strip is required for a circular window 5 ft. in diameter?

$$5 \times 3.1416 = 15.7 \text{ ft.}$$

As the mechanic does not ordinarily measure feet in tenths, the .7 should be reduced to inches; it corresponds to 8⅜ ins. from the table below. That is, the length of moulding is 15 ft. 8⅜ ins. (approx).

Problem 3.—To find the length of an arc of a circle.

Rule.—*As* 360° *is to the number of degrees of the arc so is the length of the circumference to the length of the arc.*

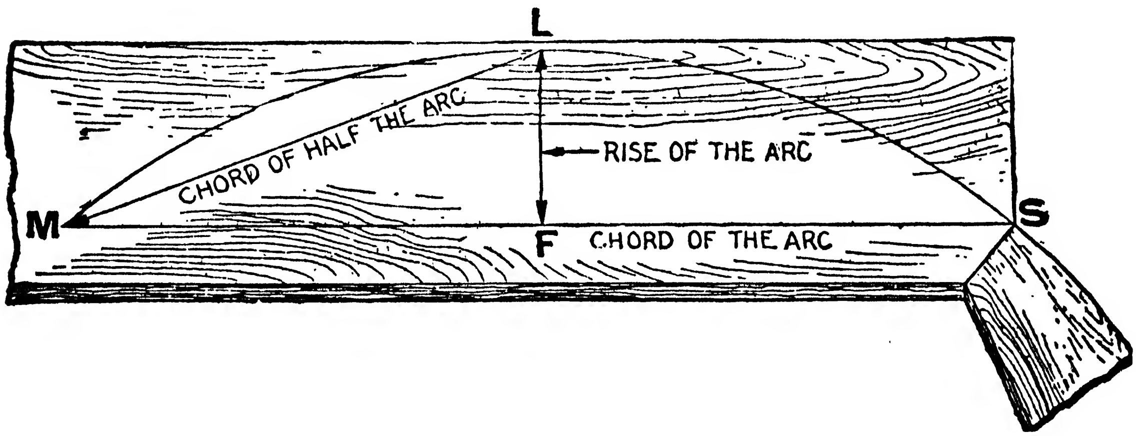


FIG. 199—***Problem 4*** *To find width of board required for plate form of circular pattern.*

Decimals of a Foot and Inches

Inch	0″	1″	2″	3″	4″	5″	6″	7″	8″	9″	10″	11″
0	.0	.0833	.1677	.2500	.3333	4167	.5000	.5833	.6667	.7500	.8333	.9167
1-16	.0052	.0885	.1719	.2552	.3385	.4219	.5052	.5885	.6719	.7552	.8385	.9219
1-8	.0104	.0937	.1771	2604	.3437	.4271	.5104	.5937	.6771	.7604	.8437	.9271
3-16	.0156	.0990	.1823	.2656	.3490	.4323	.5156	.5990	.6823	.7656	.8490	9323
1-4	.0208	.1042	.1875	.2708	.3542	.4375	.5208	.6042	.6875	.7708	.8542	.9375
5-16	0260	1094	.1927	.2760	.3594	.4427	.5260	.6094	.6927	.7760	.8594	.9427
3-8	0312	.1146	.1979	2812	.3646	.4479	.5312	.6146	.6979	7812	.8646	.9479
7-16	.0365	.1198	.2031	.2865	.3698	.4531	.5365	.6198	.7031	.7865	.8698	9531
1-2	.0417	.1250	2083	.2917	.3750	.4583	.5417	.6250	.7083	.7917	.8750	.9583
9-16	.0469	.1302	.2135	.2969	.3802	.4635	.5469	.6302	.7135	.7969	8802	.9635
5-8	.0521	.1354	.2188	3021	.3854	.4688	.5521	.6354	.7188	.8021	.8854	9688
11-16	.0573	.1406	.2240	.3073	.3906	.4740	.5573	.6406	.7240	.8073	.8906	.9740
3-4	.0625	.1458	.2292	3125	.3958	.4792	.5625	.6458	.7292	8125.	.8958	.9792
13-16	.0677	.1510	.2344	.3177	4010	.4844	.5677	6510	.7344	.8177	.9010	.9844
7-8	.0729	.1562	.2396	.3229	4062	4896	5729	.6562	7396	.8229	.9062	.9896
15-16	.0781	.1615	.2448	.3281	4115	.4948	.5781	6615	7448	.8281	9115	.9948

Example.—If the circumference of a circle be 6 feet, what is the length of 60° arc?

Let X = length of the arc, solving for X.

$$360 : 60 = 6 : X = \frac{60 \times 6}{360} = \frac{360}{360} = 1 \text{ ft.}$$

Problem 4.—To find the rise of an arc.

Rule 1.—*The rise of an arc is equal to the square of the chord of half the arc divided by the diameter.*

Rule 2.—*Length of the chord subtending an angle at the center is equal to twice the sine of half the angle multiplied by radius.*

Example.—A circular pattern 10 ft. in diam. has six plate forms. Find width of board required for these forms allowing 3 ins. margin for joints as in fig. 199.

Each plate will subtend an angle of 360 ÷ 6 = 60°
The "chord of half the arc" (mentioned in rule 1) will subtend 60 ÷ 2 = 30°.

Applying rule 2, "half the angle" = 30° ÷ 2 = 15°.

From table of "trigonometrical functions" , sine of 15° = .259, which with radius of 5 ft., becomes

sin 15° (on 10-ft. circle) = 5 × .259 = 1.295

Applying rule 2 length of chord MS. = 2 × 1.295 = 2.59

Applying rule 1 rise of arc MS, = 2.59^2 ÷ 10 = .671 ft. or $8\frac{1}{16}$ ins. **(approx.)**

Add to this 3 ins. margin for joints and obtain

width of board $8\frac{1}{16}$ + 3 = $11\frac{1}{16}$ Use 12 in. board

2. Measurement of Surfaces

(areas)

Problem 5.—To find the area of a square.

Rule.—*Multiply the base by the height.*

Example.—What is the area of a square whose side is 5 ft. as in fig. 200?

$$5 \times 5 = 25 \text{ sq. ft.}$$

Problem 6.—To find the area of a rectangle.

Rule.—*Multiply the base by the height* (*i. e., width by length*).

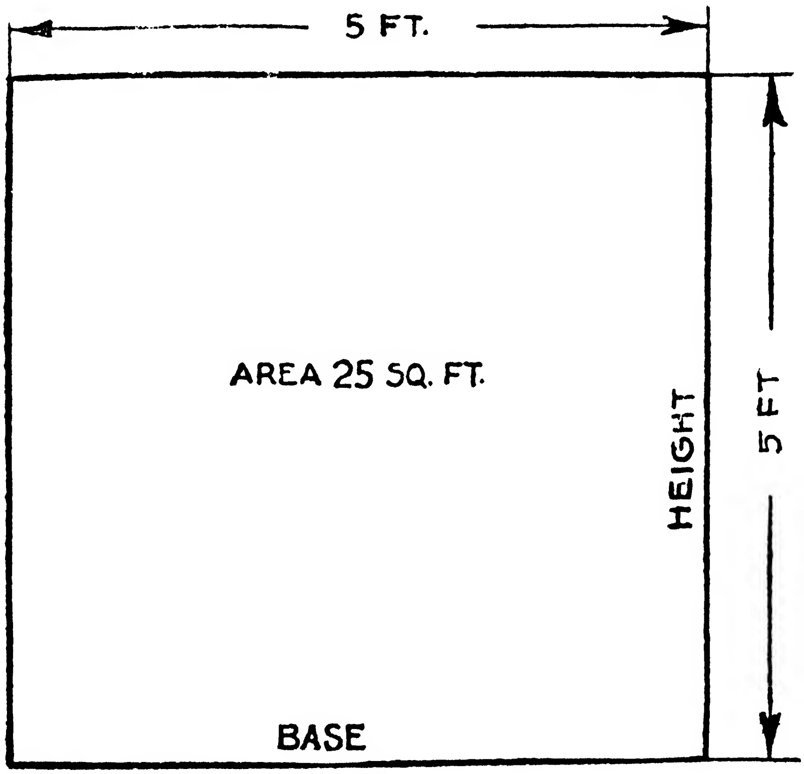


FIG. 200.—*Problem 5. Area of square.*

Example.—What is the area of a rectangle 5 ft. wide and 12 ft. long, as in fig. 201?

$$5 \times 12 = 60 \text{ sq. ft.}$$

Problem 7.—To find the area of a parallelogram.

Rule.—*Multiply base by perpendicular height.*

Example.—What is the area of a parallelogram 2 ft. wide and 10 ft. long?

$$2 \times 10 = 20 \text{ sq. ft.}$$

Problem 8.—To find the area of a triangle.

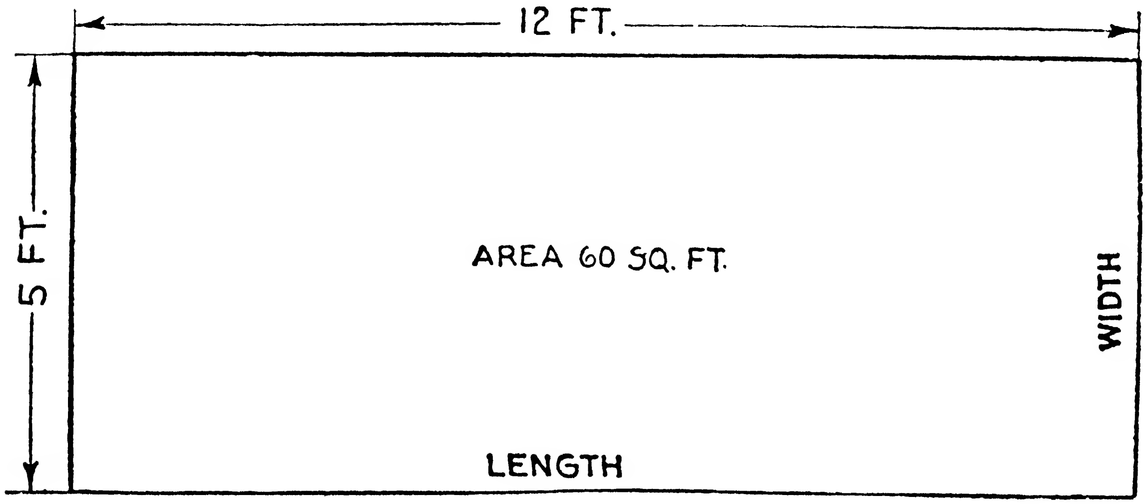


FIG. 201.—***Problem 6.*** *Area of rectangle.*

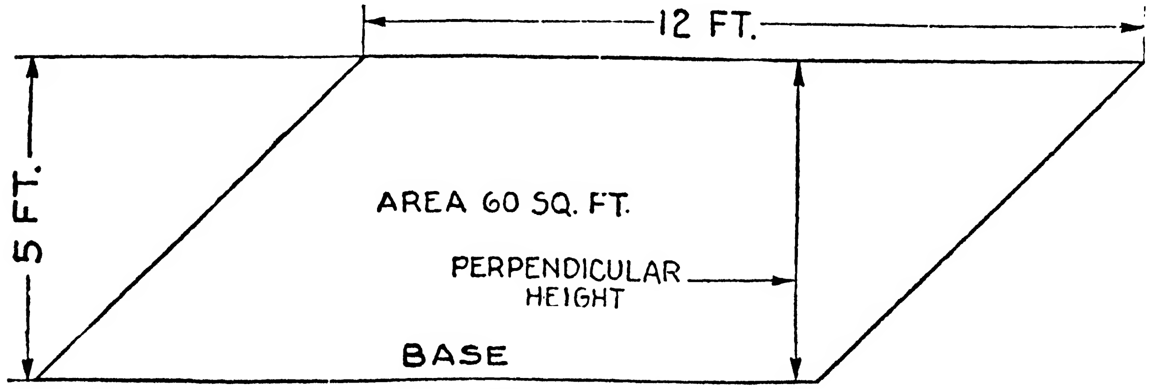


FIG. 202.—***Problem 7.*** *Area of parallelogram.*

Rule.—*Multiply the base by half the altitude.*

Example.—How many sq. ft. of sheet tin are required to cover a church steeple having four triangular sides, measuring 12 ft. (base) $\times$ 30 ft. (altitude)as in fig. 203?

$$\tfrac{1}{2} \text{ of altitude} = 15 \text{ ft.}$$

$$\text{area of one side} = 12 \times 15 = 180 \text{ sq. ft.}$$

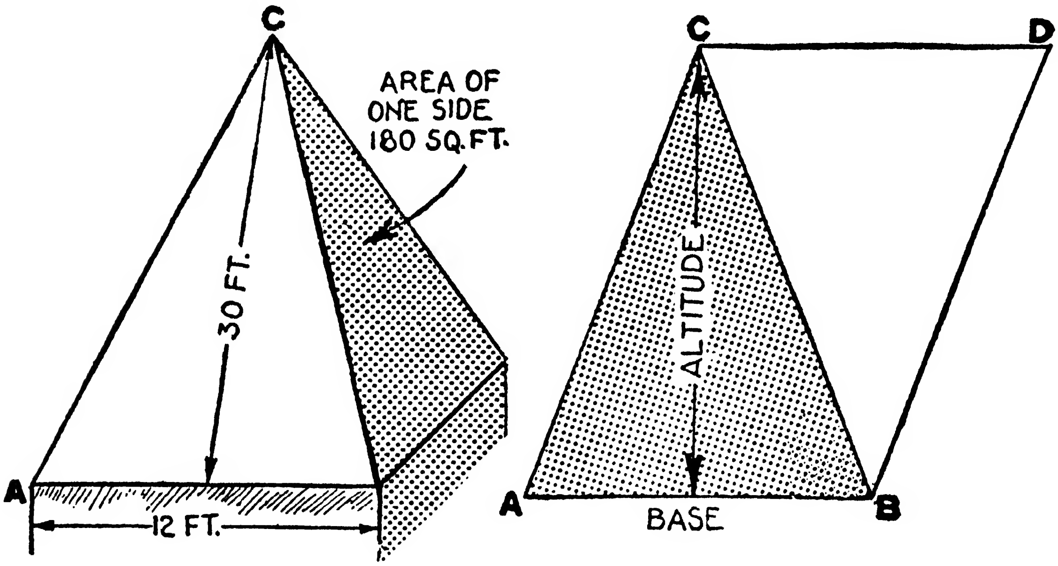
Total area (four sides) $4 \times 180 = 720$ sq. ft.

Problem 9.—To find the area of a trapezoid.

Rule.—*Multiply one-half the sum of the two parallel sides by the perpendicular distance between them.*

Example.—What is the area of the trapezoid shown in fig. 205?

Here LA and FR, are the parallel sides and MS, the perpendicular dis-



FIGS. 203 and 204.—***Problem 8.*** *Area of triangle.* An inspection of fig. 204 will show that area of triangle = base × ½ altitude because constructing a parallelogram ABCD, it is made up of two equal triangles and its area = base × altitude. Hence ½ altitude is taken in finding area of a triangle.

tance between them. Applying rule

$$\text{area} = \tfrac{1}{2}(LA + FR) \times MS$$
$$= \tfrac{1}{2}(8 + 12) \times 6 = 60 \text{ sq. ft.}$$

Problem 10.—To find the area of a trapezium.

Rule.—*Draw a diagonal, dividing figure into triangles; measure diagonal and altitudes and find area of the triangles.*

Example.—What is the area of the trapezium shown in fig. 206, for the dimensions given? Draw diagonal LR, and altitudes AM and FS.

area triangle ALR $= 12 \times {}^6/_2 = 36$ sq. ft.
area triangle LRF $= 12 \times {}^9/_2 = 54$ sq. ft.

area trapezium LARF = ...90 sq. ft.

Problem 11.—To find the area of any irregular polygon.

Rule.—*Draw diagonals dividing the figure into triangles and find the sum of the areas of these triangles.*

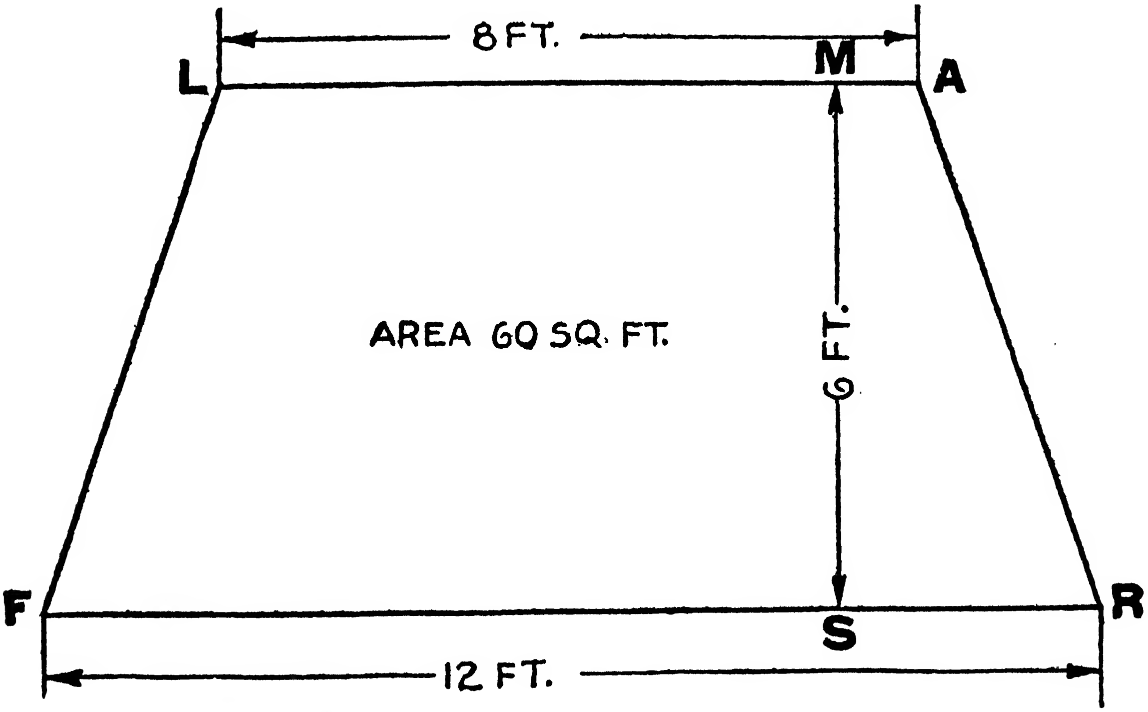


FIG. 205.—***Problem 9.*** *Area of trapezoid.*

Problem 12.—To find the area of any regular polygon when length of side only is given.

Rule.—*Multiply the square of the sides by the figure for "area, when side = 1" in the table following:*

Number of sides	3	4	5	6	7	8	9	10	11	12
Area when side =1.........	.433	1.	1.721	2.598	3.634	4.828	6.181	7.694	9.366	11.196

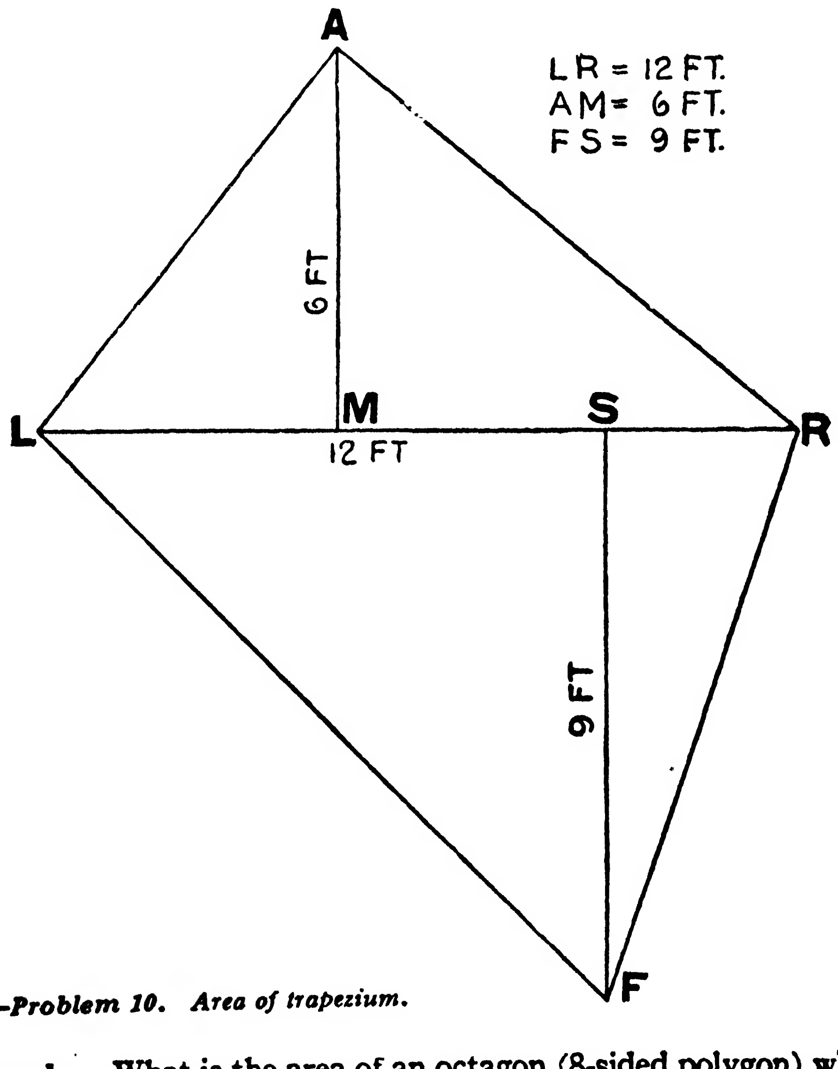


FIG. 206.—*Problem 10. Area of trapezium.*

Example.—What is the area of an octagon (8-sided polygon) whose sides measure 4 ft.

In the above table under 8, find 4.828. Multiply this by the square of one side.

$$4.828 \times 4^2 = 77.25 \text{ sq. ft.}$$

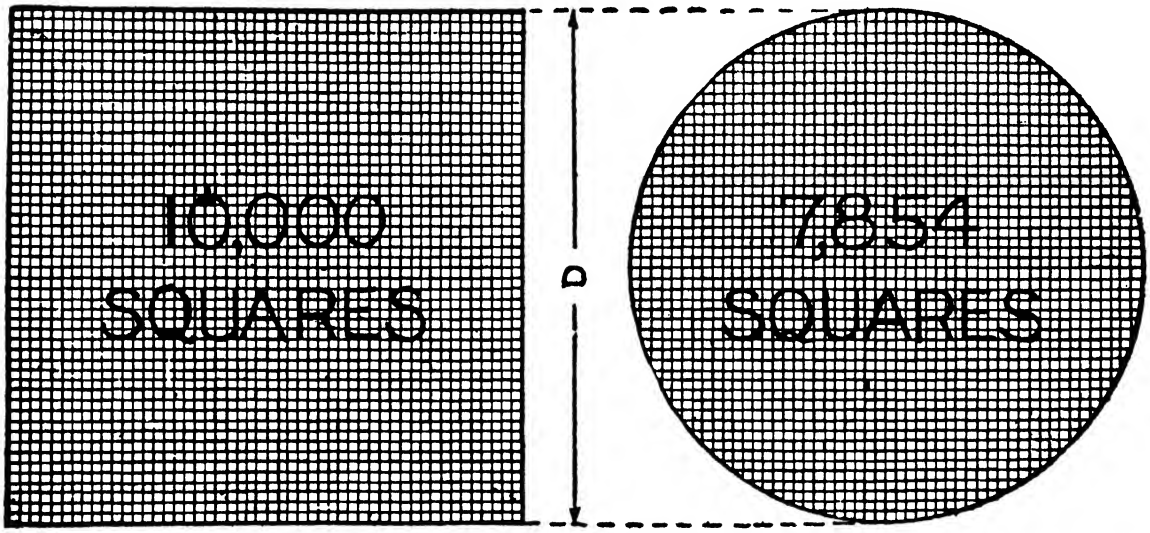
Problem 13.—To find the area of a circle.

Rule.—*Multiply square of diameter by* .7854.

Example.—What is the area of a circle 10 ft. in diameter?

$$10^2 \times .7854 = 78.54 \text{ sq. ft.}$$

Figs. 207 and 208 show why the decimal 7854 is used in finding the area of a circle.



Figs. 207 and 208.—Showing why the decimal .7854 is used to find the area of a circle. If the square be divided into 10,000 parts or small squares, a circle having a diameter D, equal to a side of the large square will contain 7,854 small squares, hence, if the area of the large square be 1 sq. in., then the area of the circle will be 7854 ÷ 10,000 or .7854 sq. ins., that is, area of the circle = .7854 × D × D = .7854 × 1 × 1 = .7854 sq. ins.

Problem 14.—To find the area of a sector of a circle.

Rule.—*Multiply the arc of the sector by half the radius.*

Example.—How much tin is required to cover a 60° sector of a 10 foot circular deck?

$$\text{length of } 60^\circ \text{ arc} = \frac{60}{360} \text{ of } 3.1416 \times 10 = 5.24 \text{ ft.}$$

The reason for the above operation should be apparent without any explanation.

Applying rule

tin required for 60° sector = 5.24 × ½ of 5 = 13.1 sq. ft.

Problem 15.—To find the area of a segment of a circle.

Rule.—*Find the area of the sector which has the same arc and also the area of the triangle formed by the radii and chord; take the sum of these areas if the segment be greater than* 180°; *take the difference if less.*

Problem 16.—To find the area of a ring.

Rule.—*Take the difference between the areas of the two circles.*

Problem 17.—To find the area of an ellipse.

Rule.—*Multiply the product of the two diameters by* .7854.

Example.—What is the area of an ellipse when the minor and major axes are 6 and 10 ins. respectively?

$$10 \times 6 \times .7854 = 47.12 \text{ sq. ins.}$$

Problem 18.—To find the circular area of a cylinder.

Rule.—*Multiply* 3.1416 *by the diameter and by the height.*

Example.—How many sq. ft. of lumber are required for the sides of a cylindrical tank 8 ft. in diameter and 12 ft. high; how many pieces 4″ × 12′ will be required?

cylindrical surface 3.1416 × 8 × 12 = 302 sq. ft.

circumference of tank = 3.1416 × 8 = 25.1 ft.

Number 4″ × 12′ pieces 25.1 ÷ $^4/_{12}$ = 25.1 × 3 = 75.3, say 76.

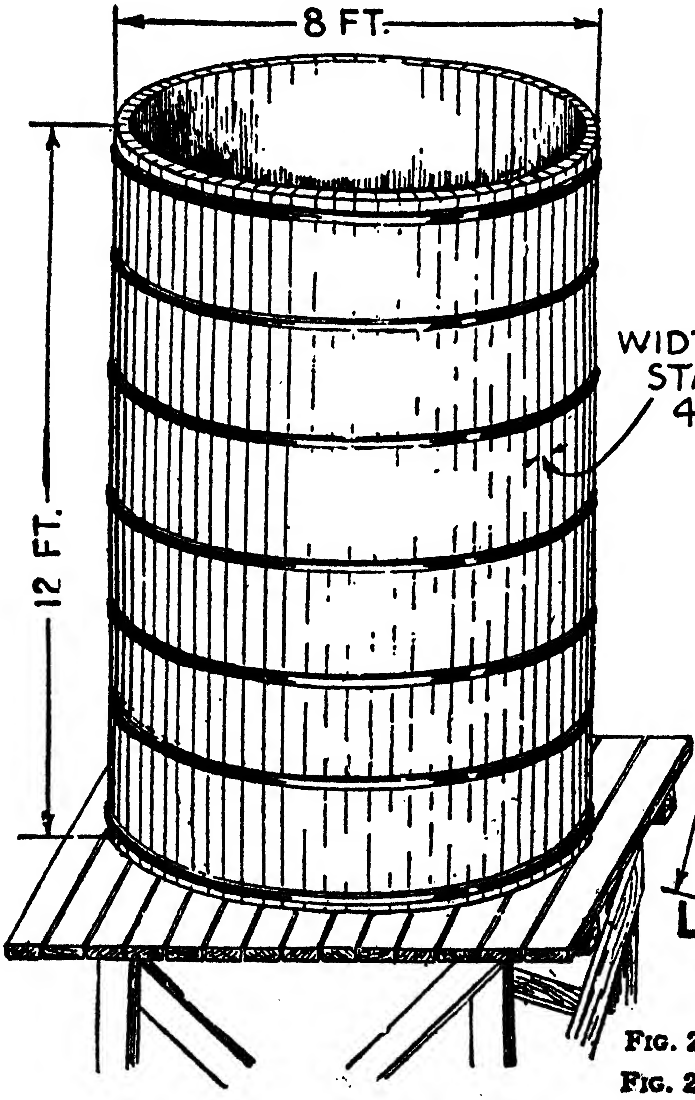
Problem 19.—To find the slant area of a cone.

Rule.—*Multiply* 3.1416 *by diameter of base and by one-half the slant height.*

Example.—A conical spire having a base 10 ft. diameter and altitude of 20 ft. is to be covered. Find area of surface to be covered.

In fig. 210, first find slant height, thus

$$\text{slant height} = \sqrt{5^2 + 20^2} = \sqrt{425} = 20.62 \text{ ft.}$$



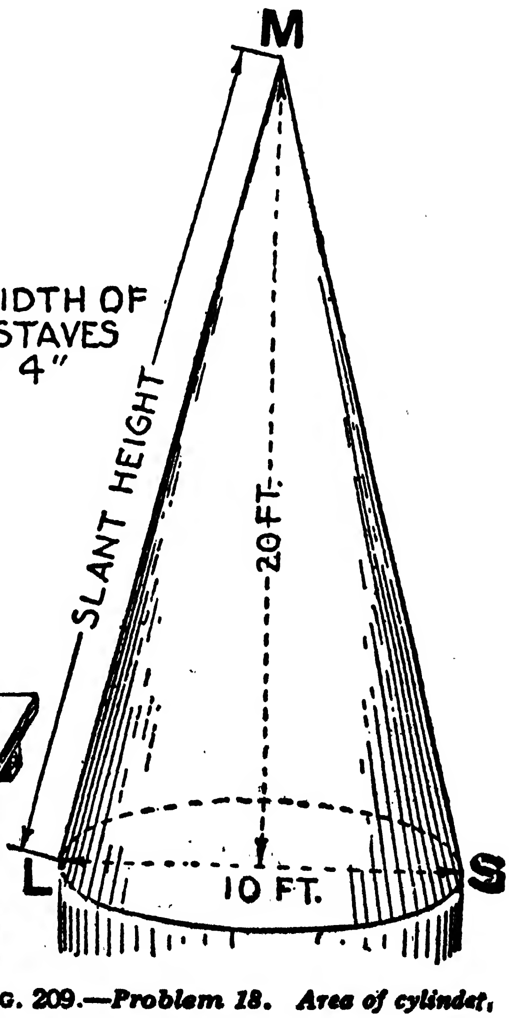


FIG. 209.—*Problem 18. Area of cylinder.*
FIG. 210.—*Problem 19. Area of cone.*

circumference of base = 3.1416 × 10 = 31.42 ft.
area of conical surface = 31.42 × ½ of 20.62 = 324 sq. ft.

Problem 20.—To find the (slant) area of the frustum of a cone.

Rule.—*Multiply half the slant height by the sum of the circumferences.*

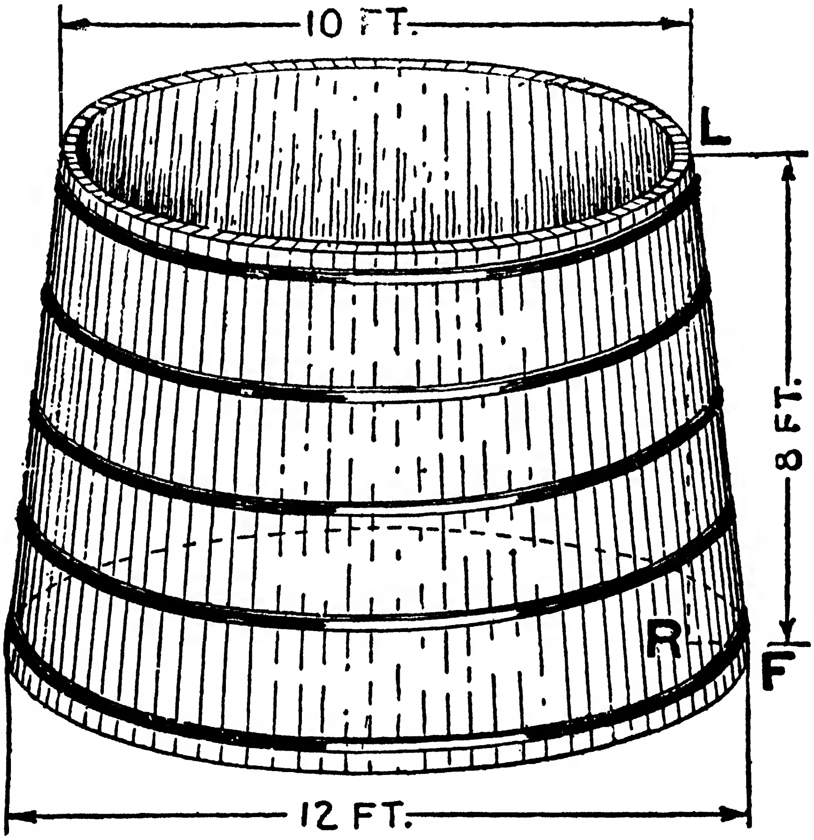


FIG. 211.—*Problem 20. Area of frustum of a cone.* This is the shape of the ordinary wooden tank seen in wind mill towers. In the figure LR = height of tank. Since the difference between the two diameters is two feet, RF = 1 ft. Hence slant height or LF = $\sqrt{1^2 + 8^2}$ = 8.06.

Example.—A tank is 12 ft in diameter at the base, 10 ft at the top, and 8 ft. high. What is the area of the slant surface?

circumference 10 ft. circle = 3 1416 × 10 = 31.42 ft.
circumference 12 ft circle = 3 1416 × 12 = 37.7 ft
sum of circumferences = 69.1 ft

$$\text{slant height} = \sqrt{1^2 + 8^2} = \sqrt{65} = 8.06$$

$$\text{slant surface} = \text{sum of circumferences} \times \tfrac{1}{2}\ \text{slant height}$$

$$= 69.1 \times \tfrac{1}{2} \text{ of } 8.06 = 278.5 \text{ sq. ft.}$$

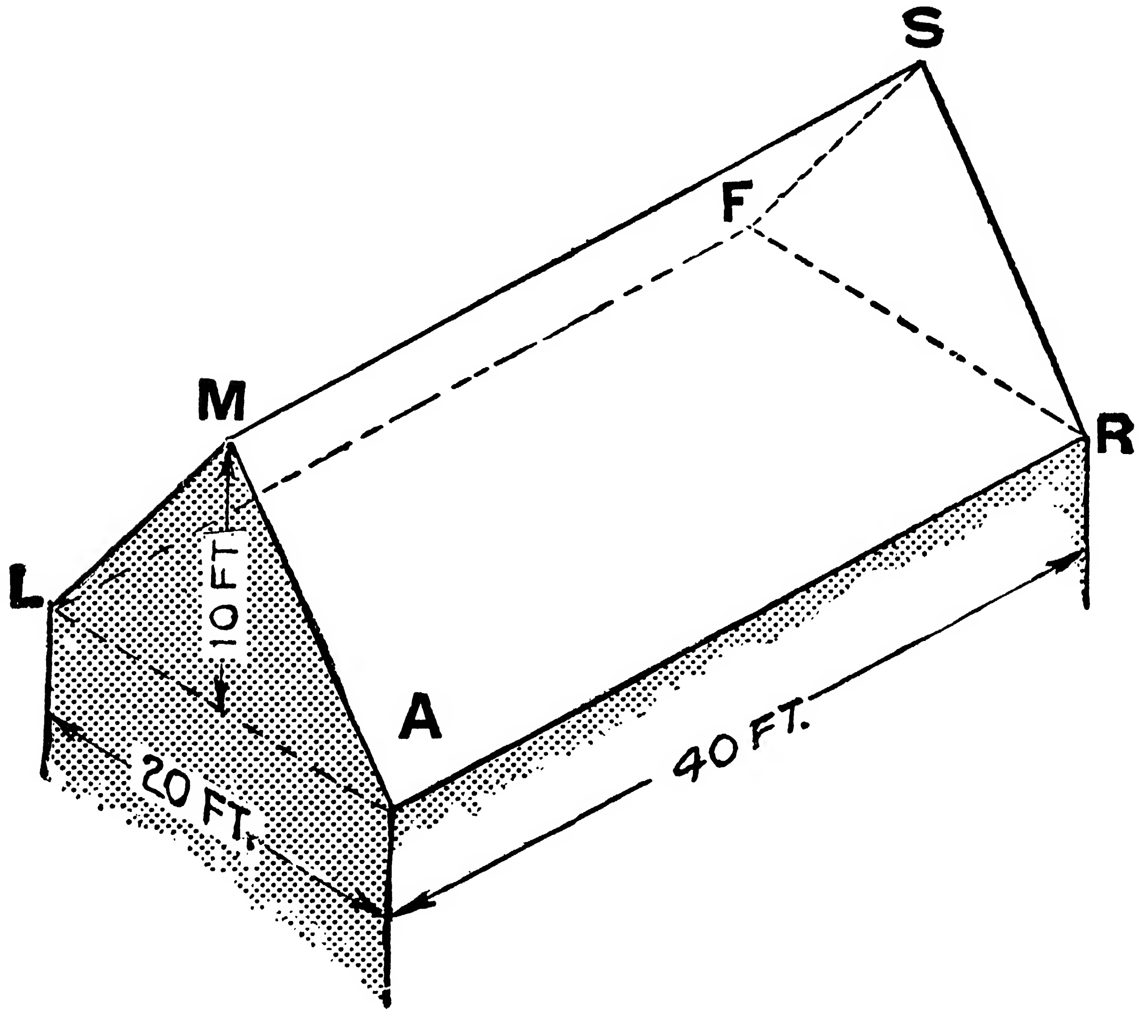


FIG. 212.—*Problem 21. Volume of rectangular wedge.*

3. Measurement of Solids

(volumes)

Problem 21.—*To find the volume of a rectangular wedge.*

Rule.—*Multiply length, breadth and one half height.*

Example.—Find the volume LARFMS of the barn shown in fig. 212.

$$40 \times 20 \times \tfrac{1}{2} \text{ of } 10 = 4000 \text{ cu. ft.}$$

Problem 22.—To find the volume of a cylinder.

Rule.—*Find the area of the base and multiply this by the length.*

Example.—What is the volume of a cylinder whose diameter is 4 ft. and length 7½ ft.?

$$\begin{array}{r} 4 \\ 4 \\ \hline 16 \end{array} \qquad \begin{array}{r} .7854 \\ 16 \\ \hline 47124 \\ 7854 \\ \hline 12.5664 \\ 7.5 \\ \hline 628320 \\ 879648 \\ \hline 94.24800 \end{array} \begin{array}{l} \\ \\ \\ \\ = \text{area of base in sq. ft.} \\ = \text{length in ft.} \\ \\ \\ \text{cu. ft.} \end{array}$$

Answer, 94.24800 cu. ft.

Problem 23.—To find the volume of a cone.

Rule.—*Multiply the area of the base by ⅓ the altitude and the product will be the volume.*

Example.—What is the volume of a cone whose diameter is 12 ft. and altitude 10 ft.?

Area of a circle $= .7854 \times$ sq. of the diameter

Area of base $= .7854 \times 12^2 = 113.1$ sq. ft.

volume $= 113.1 \times \tfrac{1}{3}$ of $10 = 377$ cu. ft.

Problem 24.—To find the volume of a sphere.

Rule.—*Multiply the cube of the diameter by* .5236.

Example.—Find the volume of a sphere whose diameter is 5 ft.

Cube of diameter

$$\begin{array}{r} 5 \\ 5 \\ \hline 25 \\ 5 \\ \hline 125 = 5^3 \end{array}$$

Diam.$^3 \times .5236$

$$\begin{array}{r} .5236 \\ 125 \\ \hline 26180 \\ 10472 \\ 5236 \\ \hline 65.4500 \text{ cu. ft.} \end{array}$$

Problem 25.—Find the volume of a segment of a sphere.

Rule 1.—*To three times the square of the radius of the segment's base, add the square of the height; then multiply this sum by the height and the product by* .5236.

Example.—How many cu. ins. in a spherical segment, having a base with diameter of 60 ins. and a height of 20 ins.?

Radius $= 60 \div 2 = 30$ ins.

Three times square of radius $= 3 \times 30 \times 30 = 2{,}700$

Add the square of the height

$$2{,}700 + (20 \times 20) = 3{,}100.$$

Multiply this by the height, $3100 \times 20 = 62{,}000$

Multiply by .5236 and obtain

$$62{,}000 \times .5236 = 32{,}463.2 \text{ cu. ins.}$$

Rule 2.—*From three times the diameter of the sphere subtract twice the height of the segment; multiply the remainder by the square of the height, and that product by* .5236 *for the volume.*

Example.—If the diameter of a sphere be 3 ft. 6 ins. what is the volume of a segment whose height is 1 ft. 3 ins.?

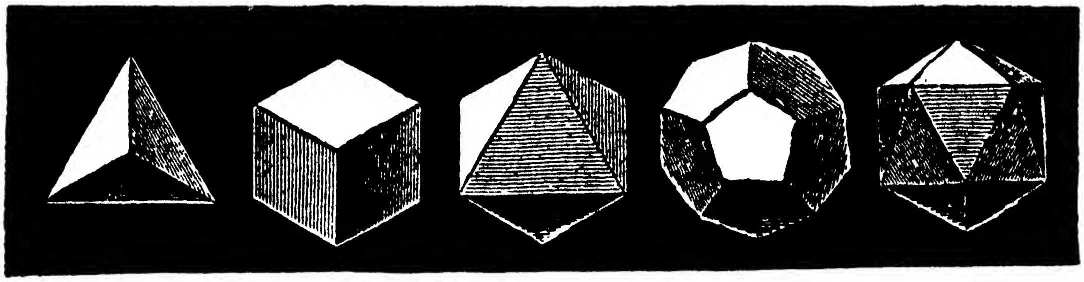
$$3 \times 3.5 = 10.5$$
$$2 \times 1.25 = 2.5$$
$$\overline{8}$$
$$8 \times 1.25 \times 1.25 \times .5236 = 6.55 \text{ cu. ft.}$$

Problem 26.—To find the volume of an irregular solid.

Rule.—1. *Divide the irregular solid into different figures; the sum of their solidities will be the solidity required.* **2.** *To find the*

solidity of a piece of wood or stone that is craggy or uneven, put it into a tub or cistern, and pour in as much water as will just cover it; then take it out and find the contents of that part of the vessel through which the water has descended and it will be the solidity required.

Problem 27.—To find the surface and volume of any of the five regular solids, figs. 213 to 217.



FIGS. 213 to 217.—*The five regular solids:* Fig. 213, tetrahedron or solid, bounded by four equilateral triangles; fig. 214, hexahedron or cube, bounded by six squares; fig. 215, octahedron, bounded by eight equilateral triangles; fig. 216, dodecahedron, bounded by twelve pentagons; fig. 217, icosahedron, bounded by twenty equilateral triangles.

Rule (surface).—*Multiply the tabular area below, by the square of the edge of the solid.*

Rule (volume).—*Multiply the tabular contents below, by the cube of the given edge.*

Surfaces and Volumes of Regular Solids

Number of Sides	NAME	Area. Edge = 1	Contents. Edge = 1
4	......Tetrahedron.........	1.7320	0.1178
6	......Hexahedron...... ..	6.0000	1.0000
8	......Octahedron..........	3.4641	0.4714
12	......Dodecahedron......	20.6458	7.6631
20	......Icosahedron..........	8.6603	2.1817

Mensuration of Surfaces and Volumes

(Summary)

Area of rectangle = length × breadth.
Area of triangle = base × ½ perpendicular height.
Diameter of circle = radius × 2.
Circumference of circle = diameter × 3.1416.
Area of circle = square of diameter × .7854.

$$\text{Area of sector of circle} = \frac{\text{area of circle} \times \text{number of degrees in arc.}}{360}$$

Area of surface of cylinder = circumference × length + area of two ends.

To find diameter of circle having given area: Divide the area by .7854, and extract the square root.

To find the volume of a cylinder: Multiply the area of the section in square inches by the length in inches = the volume in cubic inches. Cubic inches divided by 1728 = volume in cubic feet.

Surface of a sphere = square of diameter × 3.1416.
Solidity of a sphere = cube of diameter × .5236.
Side of an inscribed cube = radius of a sphere × 1.1547.

Area of the base of a pyramid or cone, whether round, square or triangular, multiplied by one-third of its height = the solidity

Diam. × .8862 = side of an equal square.
Diam. × .7071 = side of an inscribed square.
Radius × 6.2832 = circumference.
Circumference = 3.5449 × $\sqrt{\text{Area of circle.}}$
Diameter = 1.1283 × $\sqrt{\text{Area of circle}}$
Length of arc = No. of degrees × .017453 radius.
Degrees in arc whose length equals radius = 57.3°
Length of an arc of 1° = radius × .017453.
" " " 1 Min. = radius × .0002909
" " " 1 Sec. = radius × .0000048

π = Proportion of circumference to diameter = 3.1415926.
π^2 = 9.8696044
$\sqrt{\pi}$ = 1.7724538
Log. = 0.49715
$1/\pi$ = 0.31831
$\pi/360$ = .008727
$360/\pi$ = 114.59

Lineal feet............................	×	.00019	= Miles.
" yards......................	×	.0006	= "
Square inches......................	×	.007	= Square feet.

Square feet	×	.111	=Square yards.
" yards	×	.0002067	=Acres.
Acres	×	4840	=Square yards.
Cubic inches	×	.00058	=Cubic feet.
" feet	×	.03704	=Cubic yards.
Circular inches	×	.00546	=Square feet.
Cyl. inches	×	.0004546	=Cubic feet.
" feet	×	.02909	= " yards.
Links	×	.22	=Yards.
"	×	.66	=Feet.
Feet	×	1.5	=Links.
Width in chains	×	8	=Acres per mile.
183346 circular in			=1 square foot.
2200 Cylindrical in			=1 cubic foot.
Cubic feet	×	7.48	=U. S. gallons.
" inches	×	.004329	=U. S. gallons.
U. S. gallons	×	.13368	=Cubic feet.
U. S. "	×	231	= " inches.
Cubic feet	×	.8036	=U. S. bushel.
" inches	×	.000466	= " " "
Cyl. feet of wate.	×	6	=U. S. gallons.
Lbs. Avoir	×	.009	=cwt. (112)
" "	×	.00045	=Tons (2240)
Cubic feet of water	×	62.5	=Lbs. Avoir.
" inch " "	×	.03617	= " "
Cyl. feet water	×	49.1	= " "
Cyl. inch water	×	.02842	= " "
13.44 U. S. gallons of water			=1 cwt.
268.8 U. S. " " "			=1 ton.
1.8 cubic feet of water			=1 cwt.
35.88 cubic feet of water			=1 ton.
Column of water, 12 inches high, and 1 inch in diameter			=.341 Lbs.
U. S. bushel	×	.0495	=Cubic yards.
" " "	×	1.2446	= " feet.
" " "	×	2150 42	=inches.

Problem 28.—To find the volume of a cylindrical ring.

Rule.—*To diameter of body of ring add inner diameter of ring; multiply sum by square of diameter of body, and product by* 2.4674.

Example.—What is volume of an anchor ring. diameter of metal, being 3 ins. and inner diameter of ring. 8 ins.?

$3+8\times 3^2=99$ = product of sum of diameter and square of diameter of body of ring.

Then $99\times 2.4674=244.2726$ cu. ins.

Problem 29.—To find the sectional area of a pipe.

Example.—A pipe has an external diameter of 2 ins. and an internal diameter of $1\frac{3}{4}$ ins. Find its sectional area in sq. ins.

Rule.—*From the area of the greater circle subtract that of the lesser.*

$$\text{area of } 2 \odot = 2^2\times .7854 = 3.1416$$

$$\text{area of } 1\tfrac{3}{4} \odot = (1\tfrac{3}{4})^2\times .7854 = \frac{2.4053}{.7363} \text{ sq. ins.}$$

Properties of the Circle

(According to Kent)

Diameter of circle	× .88623	= side of equal square
Circumference of circle	× .28209	
Circumference of circle	× 1.1284	= perimeter of equal square
Diameter of circle	× .7071	= side of inscribed square
Circumference of circle	× .22508	
Area of circle × .90031	÷ diameter	
Area of circle	× 1.2732	= area of circumscribed square
Area of circle	× .63662	= area of inscribed square
Side of square	× 1.4142	= diam. of circumscribed circle
Side of square	× 4.4428	= circum.
Side of square	× 1.1284	= diam. of equal circle
Side of square	× 3.5449	= circum. of equal circle
Perimeter of square	× .88623	= circum. of equal circle
Square inches	× 1.2732	= circular inches

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